CONGESTION RELIEF ANALYSIS

Central Puget Sound Area Report

Prepared by:
Washington State Department of Transportation

With the assistance of:
Parsons Brinckerhoff Quade & Douglas, Inc.
Mirai Associates
PB Consult
Parametrix
ECONorthwest
Cocker Fennessy
Puget Sound Regional Council

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2.0 Summary

This chapter documents the model analysis results of various congestion-relief scenarios in the central Puget Sound region.[1] The results provide perspectives on how effective these scenarios are in reducing congestion relative to the 2025 baseline conditions.

What are the growth challenges in the region?

Growth will continue to pose a challenge to Puget Sound's transportation system with new trips and more congestion. Over the past 20 years, vehicle travel in this area increased faster than population or employment growth. While this trend has been leveling off in recent years and the number of trips per capita is expected to remain stable in the foreseeable future, travel in the region is estimated to increase by almost 50% during the next 20 years, from 8.5 to 12.4 million daily trips, primarily due to population and employment growth.

Table 2-1: Central Puget Sound Forecasted Regional Growth 2000 to 2025

1,050,000	New Residents	+32%
660,000	New Jobs	+37%
928,000	New Vehicles	+40%
1,058,000	New Commute Trips	+47%

Source: Puget Sound Regional Council

Table 2-1 shows the regional growth forecasts for the period between 2000 and 2025. Approximately 87% of the population increase is expected to occur within the Urban Growth Area (UGA), with the remaining 13% occurring outside of the UGA.

If no major additional transportation revenue is found in the next 20 years[2], only a limited amount of new roadway capacity will be added, resulting in an estimated 300% increase in total daily delay for vehicles on the Region's roadway system in 2025 (from 285,000 hours to 1,118,000 hours per day).

Travel patterns in the region are also expected to change by 2025. Travel to, within, and from Seattle will grow at a slower rate than other areas and will comprise a smaller share of all regional trips. Trip making in other parts of the region will grow faster and contribute to changes in existing travel patterns. In particular, travel to and from Snohomish County will grow by almost 70%, with many trips heading to East and South King County and as far south as Pierce County. Trips to and from Pierce and Kitsap Counties are expected to grow by almost 50%. East King County is expected to show the largest absolute increase in overall travel within the region, with an increase of over 1.2 million daily person trips (+53%).

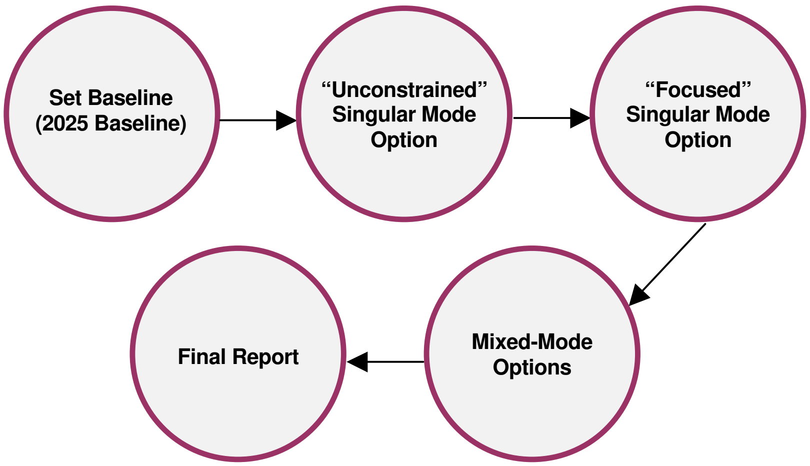
What improvements (scenarios) were modeled?

[1] The report summarizes data and results from various transportation scenarios studied during the Urban Areas Congestion Relief Analysis. The report summarizes and presents findings; it is not meant to recommend a specific strategy nor is it intended to replace, update, or propose a specific local, regional or statewide plan, policy or agreement. Information contained in this report should be used and discussed in the context of this study only.

[2] Since most analysis was done in 2004, the new transportation projects funded by the 2005 Transportation Partnership Account were not included in the analysis. However, the projects funded by the 2025 Transportation Partnership Account are not expected to be sufficient to offset the increased demand-capacity imbalance given the magnitude of the projected population and employment growth.

The focus of the study was to evaluate the congestion relief potential of system-wide transportation improvement scenarios in the central Puget Sound region. A series of data points including highways, transit, and travel demand management strategies individually and in combination at different levels were established. These data points help to assess and discern differences between different strategies as well as the level of investment and the results of congestion relief as predicted by computer models.

Figure 2-1: The Study Process



As shown in Figure 2-1, the scenarios were developed in phases. Eight different year 2025 scenarios were developed and modeled using the PSRC regional forecasting model, assuming the same future land use and total number of trips. They include a baseline scenario (included only committed and funded projects), three scenarios that focused exclusively on roadways, transit, or value pricing, and four mixed scenarios that included investments in more than one mode or type of capacity improvement. In addition, two capacity-unconstrained forecasts were developed to provide an analysis reference point. The unconstrained forecasts were used to identify the highest demand corridors for both highway and transit. The capacity-unconstrained highway forecast assumed that there was sufficient number of lanes to accommodate all travel during peak traveling period, and the unconstrained transit forecast assumed an extensive transit system conveniently accessible to everyone throughout the region.

Through computer modeling, the study evaluated transportation performance and the impacts of each scenario at both a region-wide and a corridor level. For the corridor-level analysis, 13 existing major corridors were identified. The major north-south corridors include: Interstate 5 (split into four corridors), Interstate 405 (split into two corridors), State Route 16 from Tacoma to Bremerton, and State Route 167 from Puyallup to Renton. The major east-west corridors are: Interstate 90 from Seattle to North Bend (split into two corridors), State Route 520 from Seattle to Redmond, State Route 522 from Woodinville to Monroe, and State Route 18 from I-5 in South King County to I-90 near North Bend.

Three additional analyses were conducted to evaluate the impact that specific improvements or programs would have on the region. The additional analyses include: (1) enhanced Transportation Demand Management (TDM) and Transportation Systems Management (TSM) strategies; (2) a new north-south parallel corridor in East King County; and (3) a High Occupancy Toll (HOT) lane network.

What were the model results?

The scenarios were evaluated to answer the following three questions:

1. How well does each scenario reduce travel delay?
2. What are the estimated costs and benefits of each scenario tested?
3. What are some of the potential impacts to the environment under each scenario?

How well does each scenario reduce congestion?

Each scenario was modeled to assess the extent to which it reduced roadway congestion under a set of analysis metrics. The analysis metrics include system-level and corridor-specific indicators related to delay for persons, vehicles and trucks, hours of congestion each day, and travel time on major freeway corridors.

The computer model predicted that if people continue to travel as they do today, total vehicle delay would increase dramatically in the 2025 Baseline Scenario to a level approaching 300% higher than today. All of the scenarios tested would reduce delay compared with the 2025 Baseline scenario. On a per-vehicle basis, many of the scenarios would reduce delay to levels that are comparable to, but not better than current levels. However, total delay at the system level will remain higher than today even under the most aggressive investment scenarios analyzed. This is due in large part to the increased travel associated with forecasted growth in population and employment in the region.

Compared to the 2025 Baseline Scenario, the model predicted that all scenarios would improve peak period travel times for general-purpose (GP) traffic and transit trips between key regional activity centers. For the scenarios that add substantial roadway capacity, 2025 travel times for GP traffic would be comparable to today's conditions. Scenarios that consider further investments in exclusive high-capacity transit (HCT) and/or expanded express bus service would save travel time for transit patrons.

The analysis also estimated the number of daily persons served at selected points on major corridors. This metric indicates how many people are able to travel to and from their destinations on their preferred routes relative to the theoretical demand obtained from the unconstrained highway capacity model run. The model indicated that most of the scenarios accommodated a high proportion of the capacity-unconstrained demand in major travel corridors.

Comparing the model results among the scenarios, the following observations were made:

- The model estimated that the 2025 Baseline Scenario would result in a 300% increase in total daily delay for vehicles on the region's roadway system compare to the existing condition.
- Most of the freeway corridors would require several additional lanes to meet the theoretical unconstrained highway demand during the peak period. For example, much of I-5 through Seattle north to Everett would require at least four more lanes in each direction, while I-405 through Bellevue would require up to six more lanes in each direction.
- Transit ridership would increase more than tenfold if a virtually ubiquitous transit system was available that featured frequent service, high and reliable speeds, and direct access throughout the region.
- Pricing of the full freeway/arterial system was very effective in reducing congestion and improving travel times alternative travel options could be provided for trips diverted from highways. Pricing did cause trips to shorten in length, thereby lowering persons served at some locations along major corridors in the region.

- None of the scenarios analyzed would reduce region total delay to below today's level. However, in specific corridors the congestion levels could be reduced substantially from levels forecast for the 2025 Baseline. In other corridors where reducing congestion was more difficult, transit could play an important role in moving a high proportion of people, especially during peak travel periods.
- Highway investments tended to generate more benefits per dollar of investment than did the transit investments. However, transit investments tended to generate higher benefits per transit trip than highway investments did per highway trip. However, the model indicated that none of the investment scenarios without value pricing could produce quantifiable annual benefits that exceeded the corresponding annualized costs. The sheer scale of improvements envisioned in the scenarios tested may account for this result, due to diminishing returns in user benefits as more and more capacity is added at increased costs.
- Transit-oriented scenarios were effective in improving transit travel times, but their effect on congestion was small. Transit operating on exclusive guideways or HOV facilities was more effective in certain corridors where high population and employment densities exist.
- Adding value pricing strategies to a scenario with a mix of highway and transit capacity improvements produced a large increase in benefits with a relatively small additional cost. Value pricing resulted in changes of travel behavior, including shifts to different modes, different routes, and different times of the day, which helped to reduce delay and increase system efficiency.

The additional analysis of TDM and TSM strategies, adding a new north-south corridor in East King County, or provision of a HOT lane network all would contribute to further delay reductions.

What are the estimated costs of each scenario?

Most of the scenarios analyzed would cost tens of billions of dollars. The capital costs, in current dollars, range from approximately $24 - $32 billion for the scenario that focuses on transit investments (Transit Focus Scenario) to $83 - $109 billion for the scenario that combines high investments in both highway and transit facilities (Mixed Scenario – Highway and Transit Intensive). The scenario with regional roadway variable value pricing (Pricing Focus Scenario) does not involve major roadway infrastructure investment, so the capital costs are much lower than the other scenarios.

Operations and maintenance (O&M) costs are generally much higher for transit-oriented scenarios than for highway-oriented scenarios. The scenarios with value pricing, especially the Pricing Focus Scenario, would also have relatively high O&M costs because of ongoing operating, administration and enforcement activities associated with region wide tolling. A portion of revenues collected from tolls could be used to offset these costs. The O&M costs estimated in this study are above and beyond the estimated $1.5 billion in annual costs needed to maintain and operate the existing transportation system (roadway and transit) in the central Puget Sound region.

The ability to fund the various improvements was not considered. It is conceivable that potential funding mechanisms for investments measured in the tens of billions of dollars — such as a substantial increase in the gas tax — may affect travel behavior, and thus alter the mix of supply and demand measures required to mitigate congestion delays. The scenarios with value pricing would generate revenues, although this study has not presumed how those revenues might be spent.

What are the potential impacts to the environment for each scenario?

The purpose of the environmental review was to identify the primary environmental factors contributing to the costs of each scenario, as well as the major areas where environmental impacts could be anticipated. The following observations can be made:

- All except the Pricing Focus Scenario involve substantial right-of-way needs and associated property impacts, and impacts to wetlands and streams. These effects were reflected in the cost estimates. The greatest impacts would be associated with highway-widening improvements. Most of the transit improvements were assumed to occur within existing transportation rights-of-way, usually on aerial guideways. It is very likely that project level assessment may have significantly more right of way needs. In that case, the cost of the scenarios that involve transit improvements will be even higher than estimated3.
- Air quality impacts are primarily associated with highway improvements. Transit improvements and value pricing strategies are anticipated to reduce vehicle trips and therefore reduce air pollutant emissions. Air pollutant emissions would be lowest under the value pricing scenarios.
- Noise levels are expected to be highest with the highway-oriented scenarios. Transit noise levels are expected to be relatively lower, while value pricing scenarios would have the effect of moving traffic (and noise) from one facility to another.
- Low-income and/or minority communities would experience both impacts and benefits related to the transportation scenarios. These communities may experience direct impacts such as right-of-way acquisition and increases in noise and air pollutants, primarily associated with the highway-intensive scenarios. Conversely, these and other populations will benefit from the provision of additional transportation capacity under all scenarios. Pricing effects on low-income and/or minority communities would depend on the toll rates set, the potential use of toll revenues, and the economic benefits (jobs created) resulting from reduced delay. Projects implemented elsewhere show that priced lanes are used by a broad cross-section of income and population groups.
- The scenarios are expected to have various degrees of impact on future land development patterns. But the impact will be somewhat limited by the growth management regulations in place within the region and by the small percentage of transportation capacity added outside of the adopted urban growth areas. The mixed scenarios are the most likely to be consistent with land use plans and policies in that they provide multiple transportation options and a more balanced system. While overall land use impact is difficult to assess, the highway-oriented scenarios are expected to have the most potential for conversion of existing land uses to roadway functions due to right-of-way needs. The highway-oriented scenarios have the most potential for conversion of existing land uses to roadway functions due to right-of-way needs. The effects of value pricing on land use have not been determined and would depend on the magnitude of the variable value pricing structure and how the revenues are put to use. Pricing could potentially lead to a number of indirect land use effects, including home and employment location decisions and the price of land.

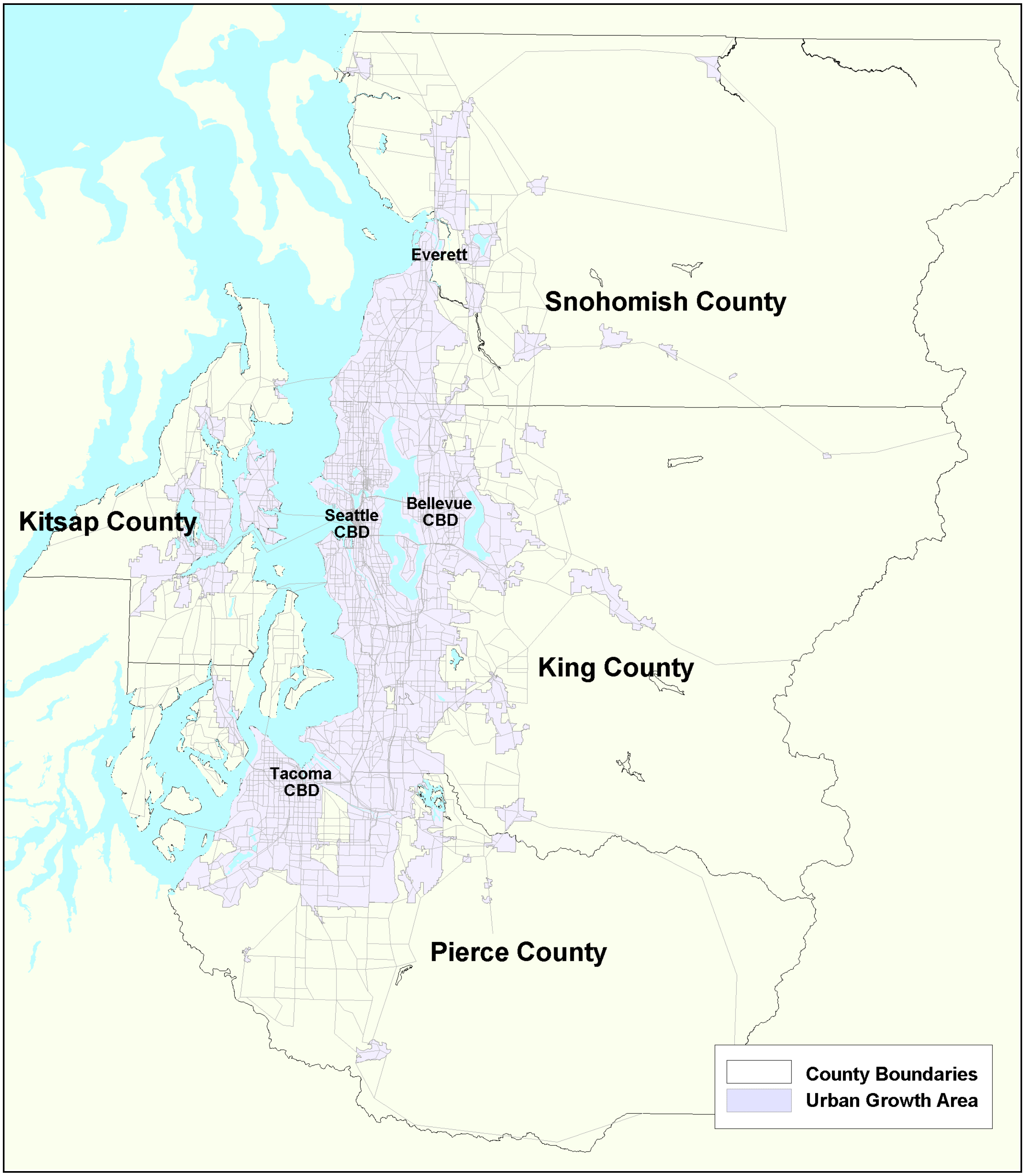
The environmental assessment focused on environmental effects at the system level. Due to lack of design details, corridor-specific environmental reviews were not performed.

3 Transit-related improvements would require additional right-of-way for park-and-ride facilities and transit vehicle maintenance and storage facilities. Transit right-of-way needs were also identified in specific corridors where the need was apparent.

2.1 Study Area Definition

The central Puget Sound region is the largest population and employment center in Washington State. The study area for the Congestion Relief Analysis includes Snohomish, King, Pierce, and Kitsap Counties (see Figure 2-2). Among the urban centers included in the study area are Everett, Seattle, Bellevue, Tacoma, and Bremerton.

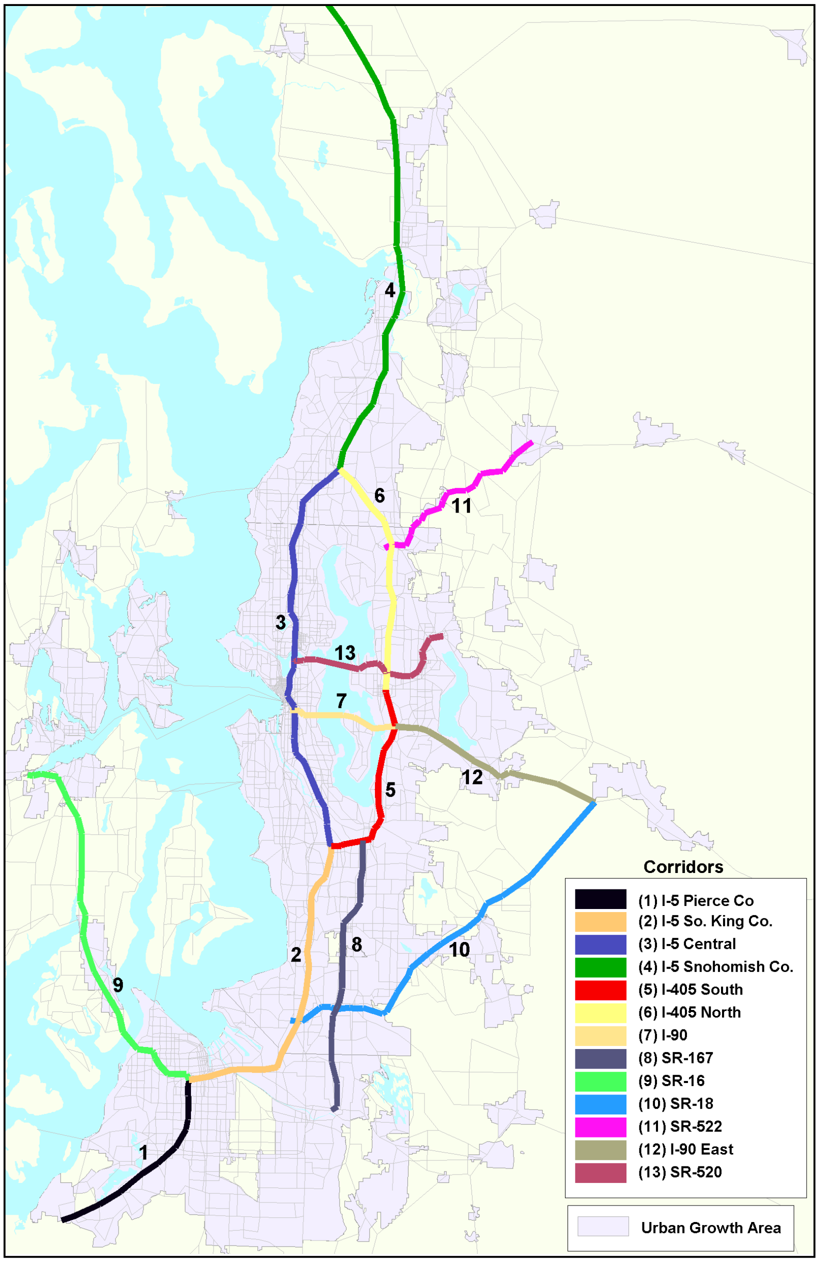
Figure 2-2: Central Puget Sound Region Study Area



2.2 Major Corridors

The study evaluates transportation performance and impacts at both region-wide and corridor levels for a number of different future scenarios. For the corridor-level analysis, 13 major corridors were identified (see Figure 2-3). A corridor is a major roadway segment that either connects two major activity centers or two major roadway facilities.

Figure 2-3: Study Corridors in the Central Puget Sound Region



The major north-south corridors are:

Interstate 5 in the central Puget Sound region was split up into four corridors for analysis: from Thurston County Line to SR-16, from SR 16 to I-405 (Tukwila), from I-405 (Tukwila) to I-405 (Lynnwood)[4], and from I-405 (Lynnwood) to Skagit County Line;

Interstate 405 is split into two corridors for this study: from I-5 (Tukwila) to downtown Bellevue, and from downtown Bellevue to I-5 (Lynnwood);

State Route 16 from Tacoma to Bremerton; and

State Route 167 from Puyallup to Renton.

The major east-west corridors are:

Interstate 90 from Seattle to North Bend. This section of I-90 was split into two corridors: from I-5 to I-405 and from I-405 to SR 18;

State Route 520 from I-5 to Redmond;

State Route 522 from Woodinville to Monroe; and

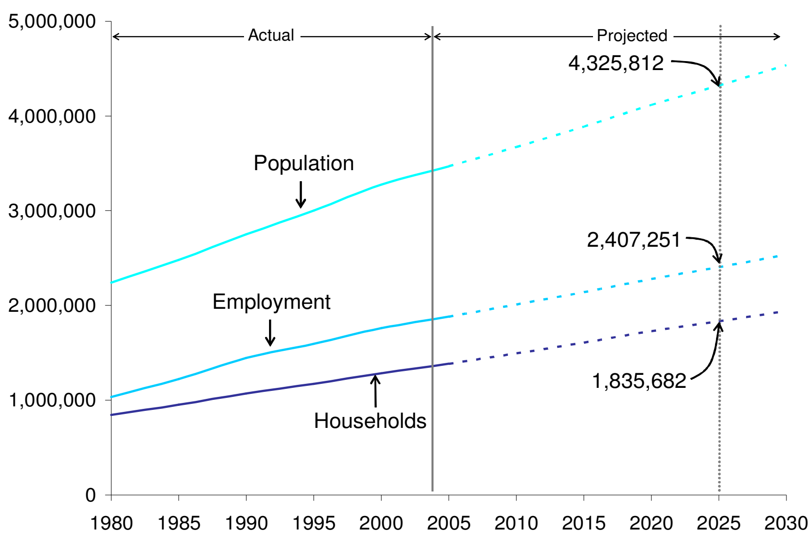
State Route 18 from I-5 (Renton) to I-90 (North Bend).

4 The I-5 corridor through central Seattle was further divided into three sections to provide more detailed data analysis.

2.3 Historical, Existing, and Future Population and Employment Patterns

Historical data on population and employment show that the central Puget Sound region has been growing steadily over the past twenty years. As shown in Figure 2-4, population and employment forecasts indicate that this growth will continue in the future.

Figure 2-4: Puget Sound Past Trend and Future Forecast



Source: PSRC 2002 Small Area Forecasts

From 2000 to 2025, forecasts indicate that the region's population will increase by nearly 1,050,000 residents, a 32% increase from approximately 3.3 million in 2000 to 4.3 million in 2025. The region's employment levels will experience an increase of similar scale of nearly 660,000 jobs (a 37% increase). These dramatic increases in population and employment will bring an additional 928,000 vehicles into the region, an increase of 40%.

Figure 2-5 illustrates that growth in population and employment is not expected to be evenly distributed throughout the region. The majority of the region's population growth is expected to occur outside of King County (63%), while the majority of the employment growth is expected to occur in King County (62%). Within King County, approximately 38% of the County's total employment growth and 32% of the County's total population growth is expected to occur in Seattle.

Forecasts indicate that approximately 87% of the population increase is expected to occur within the Urban Growth Area (UGA), with the remaining 13% occurring outside of the UGA. Figure 2-6 shows the individual counties growth into and outside of the UGA. King and Pierce Counties have a higher percentage of growth occurring within the UGA than the regional average, while Kitsap and Snohomish Counties have a lower percentage.

Figure 2-5: Forecasted Employment and Population Change 2000 to 2025

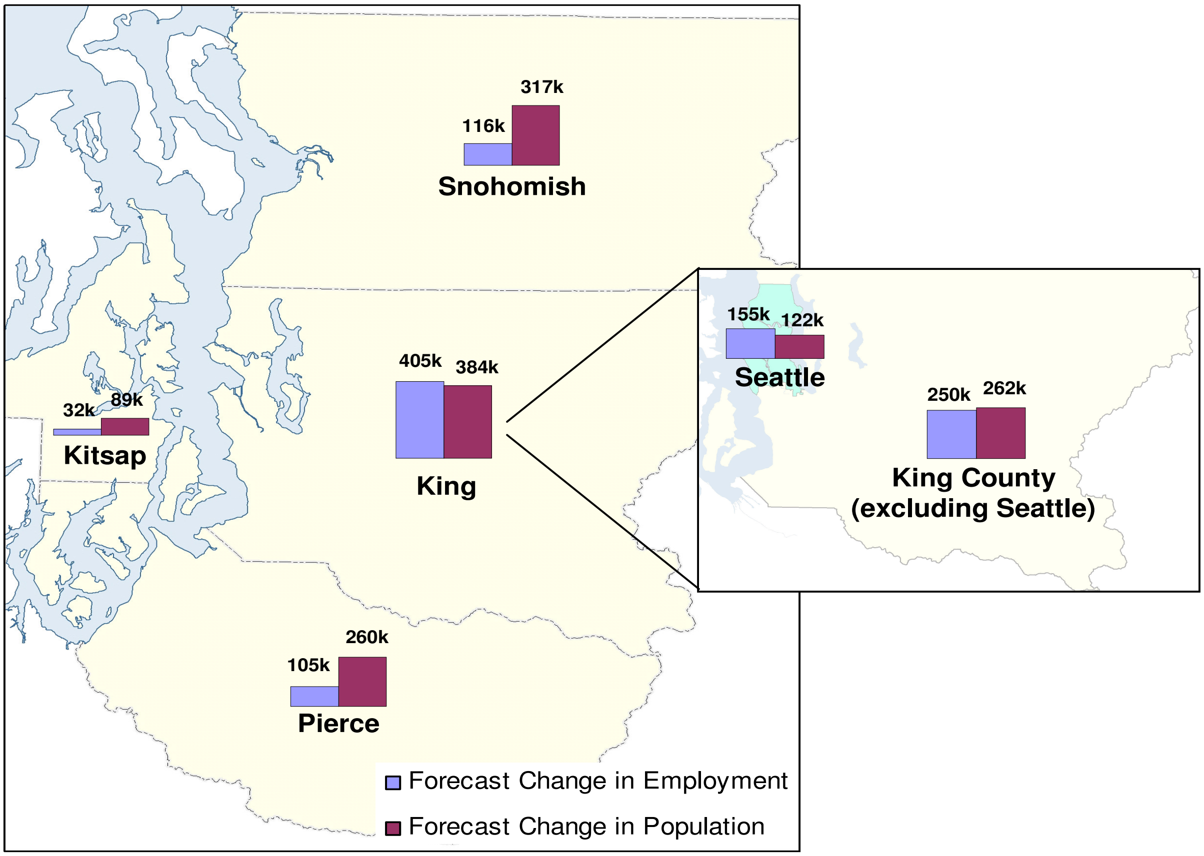
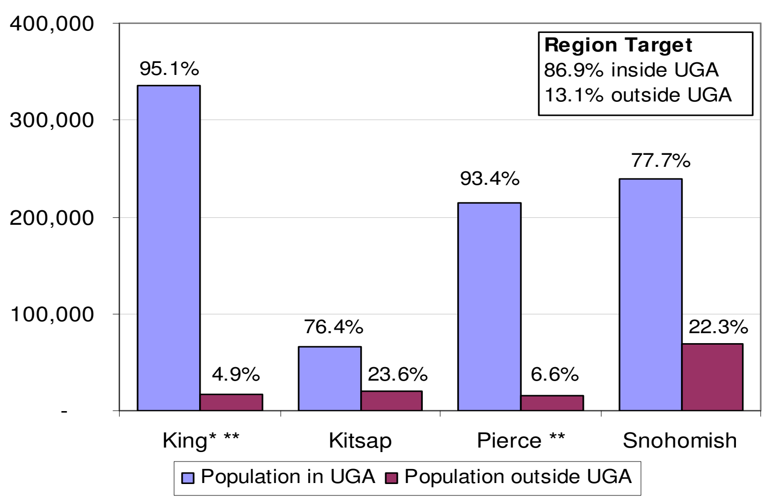


Figure 2-6: 2000 to 2025 Targets for Population Growth Inside and Outside UGA

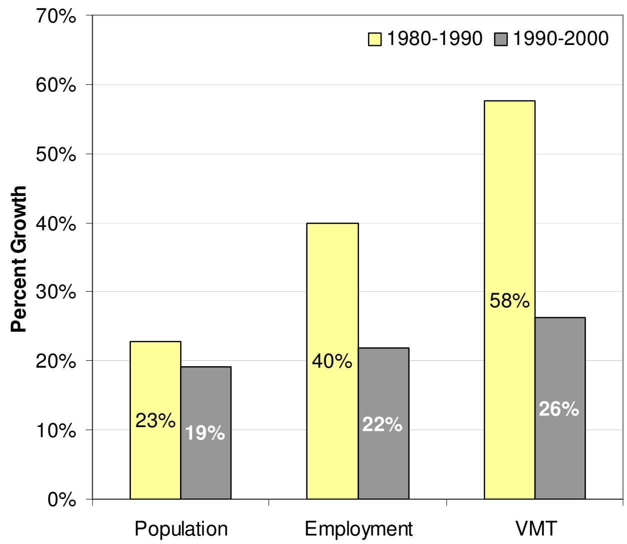


*Group quarters population assumed into the UGA.
**Targets adopted to 2022, extrapolated to 2025.

Source: PSRC Vision 2020 Monitoring "Growth Management by the Numbers: Population, Household, and Employment Growth Targets in the Central Puget Sound Region", November 2004.'"

2.4 Historical, Existing, and Future Travel

Figure 2-7: Population and Employment Growth vs. VMT Growth 1980-2000



Source: PSRC 2002 Small Area Forecasts (pop/emp)
Highway Performance Monitoring System, WSDOT

Over the past 20 years, vehicle travel increased faster than population or employment growth (see Figure 2-7). Much of this growth is the result of changing family lifestyles such as two-worker households, along with the growing affluence of the population. Between 1980 and 1990, population and employment grew by approximately 23% and 40% respectively. During that same period, growth in vehicle miles traveled (VMT) was almost 58%. During the 1990s, growth was somewhat slower, but still shows growth in vehicle travel outpacing population and employment growth: a 19% increase in population, a 22% increase in employment, and a 26% increase in VMT.

An increase in vehicle travel is expected to continue in the future, primarily due to the forecasted growths in population and employment.

Table 2-2: System-Wide Summary of Travel Forecasts

Table 2-2 and Figure 2-8 summarize travel characteristics for 1998 and the 2025 Baseline Scenario. The 2025 Baseline Scenario assumes existing facilities, plus committed projects prior to the 2005 legislative session. It includes projects that are under construction or have funding secured as part of the state's Nickel Funding program or Sound Transit Phase I.

	1998	**2025 Baseline**	**Change 1998 - 2025**
Daily Total Person Trips	12,081,600	17,902,400	+48%
Daily Total Vehicle Trips	8,545,600	12,382,700	+45%
Total Daily Vehicle Miles Travel (VMT)	72,883,900	109,061,300	+50%
Lane Miles (Fwy and Expressways)	2,320	2,360	+2%
Lane Miles (All Other Facilities)	9,940	9,980	0%
Daily Transit Service Hours	13,100	24,900	+90%
Total Daily Vehicle Hours of Delay	285,500	1,118,400	+292%
Daily Commercial Vehicle Hours of Delay	33,800	137,400	+307%

As shown in Table 2-2 and Figure 2-8, total daily person trips, vehicle trips, and vehicle miles traveled (VMT) are forecast to increase by approximately 45 to 50% by 2025.

Figure 2-8: Growth in Trips, VMT, Lane Miles, and Transit Service (1998-2025 Baseline)

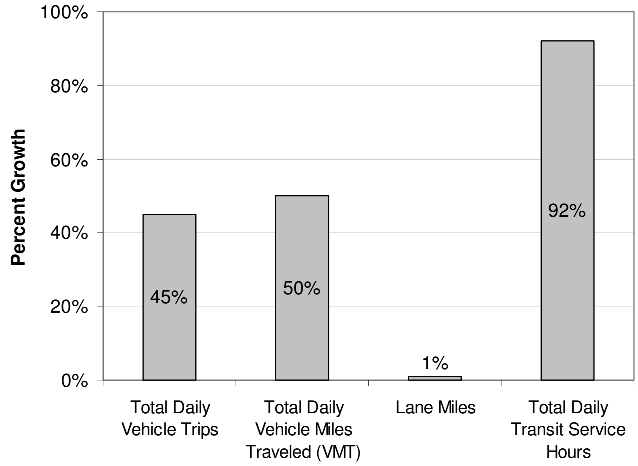
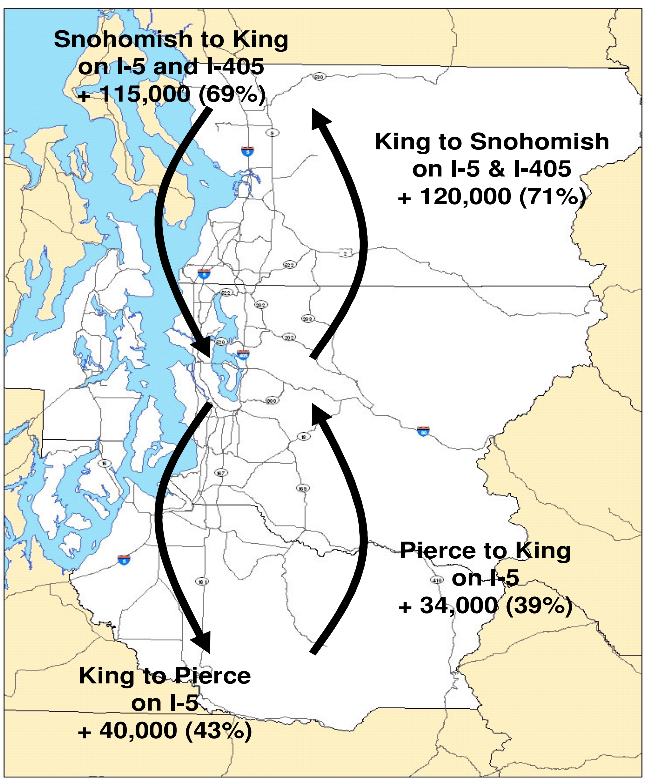


Figure 2-9: Change in Intra-regional Travel Patterns 2000 to 2025



During this same time period, assuming there is no new significant transportation revenue, lane miles will increase at a much slower rate – by approximately 1%. Daily transit service hours will increase by approximately 90% by the year 2025, due to expanded bus service and the addition of light rail, commuter rail, and monorail to the transit system. By 2025, this increase in travel and only slight increase in roadway lane miles will result in an approximate 300% increase in vehicle hours of delay.

Travel patterns in the region are also expected to change by 2025, due in large part to significant population and employment growth in parts of the region outside of Seattle. This will result in more trips being made to/from those areas as demonstrated in Figure 2-9. The model indicated that the share of regional trips to, within, and from the City of Seattle would decrease from 22% today to around 18% in 2025. Conversely, travel in other parts of the region will grow faster. In particular, travel to and from Snohomish County will grow by approximately 70%, with many trips heading to East and South King County and as far south as Pierce County. Kitsap County will generate more trips to Pierce, King, and Snohomish counties. Trips to and from Pierce and Kitsap counties are expected to grow by almost 50%. East King County is expected to show the largest increase within the region, with an increase of over 1.2 million daily person trips (+53%).

2.5 Scenario Configurations

Eight transportation scenarios were modeled in the central Puget Sound region. The scenarios were developed to represent a range of possible options for reducing congestion. The scenarios were then modeled to see how effective they are in reducing congestion, and at what cost. The modeling began with existing conditions and a 2025 Baseline Scenario (only includes projects with committed funding prior to 2005), followed by three scenarios that focused exclusively on roadways, transit, or value pricing, and four mixed scenarios that included adding capacities in more than one mode.

In order to help frame the scenarios, two capacity-unconstrained forecasts were developed: the Unconstrained Highway Demand Analysis assumed there was no congestion, and the Unconstrained Transit Demand Analysis assumed a virtually ubiquitous (i.e., present everywhere) transit network that provided a high level of transit access. The unconstrained forecasts were used to identify the highest travel demand corridors for both highway and transit.

Additional analyses were conducted to examine the congestion relief effects of travel demand management and efficiency strategies (TDM/TSM), a new parallel corridor route, and a High-Occupancy Toll (HOT) lane network.

Existing (1998) Condition

The Existing Condition is the system in the 1998 regional model developed by the Puget Sound Regional Council (PSRC). Some HOV lanes completed as of 2002 were also added to the existing network.

Figure 2-10 and Figure 2-11 show the number of general-purpose and HOV lanes included in the Existing Condition Scenario. The Existing Condition assumes 3.9 million annual bus equivalent revenue hours. Figure 2-12 shows transit service assumed for the Existing Condition (this map shows 1998 transit service).

Figure 2-10: General-Purpose (GP) Lanes Included in the Existing Condition Scenario

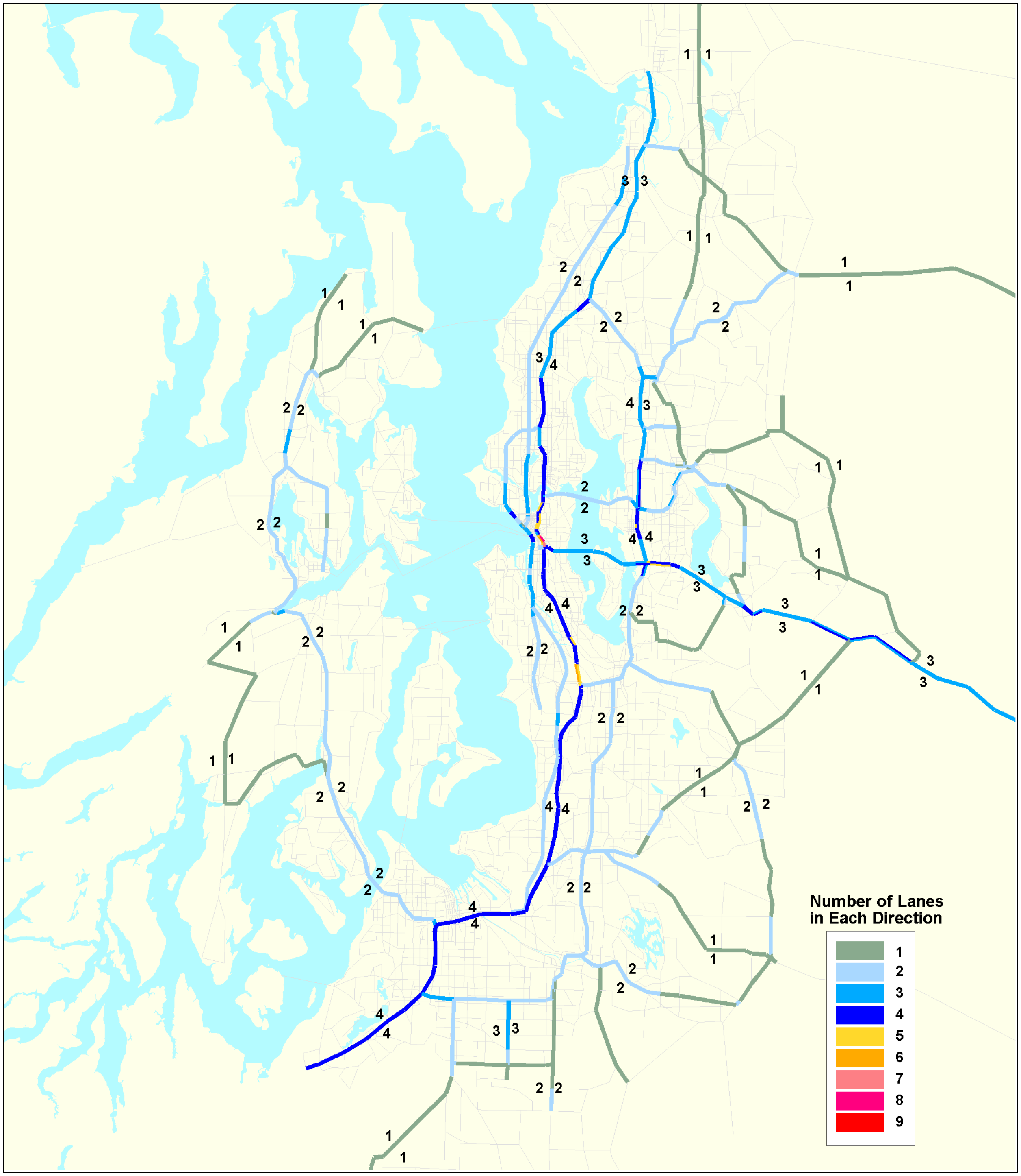


Figure 2-11: HOV Lanes Included in the Existing Condition Scenario

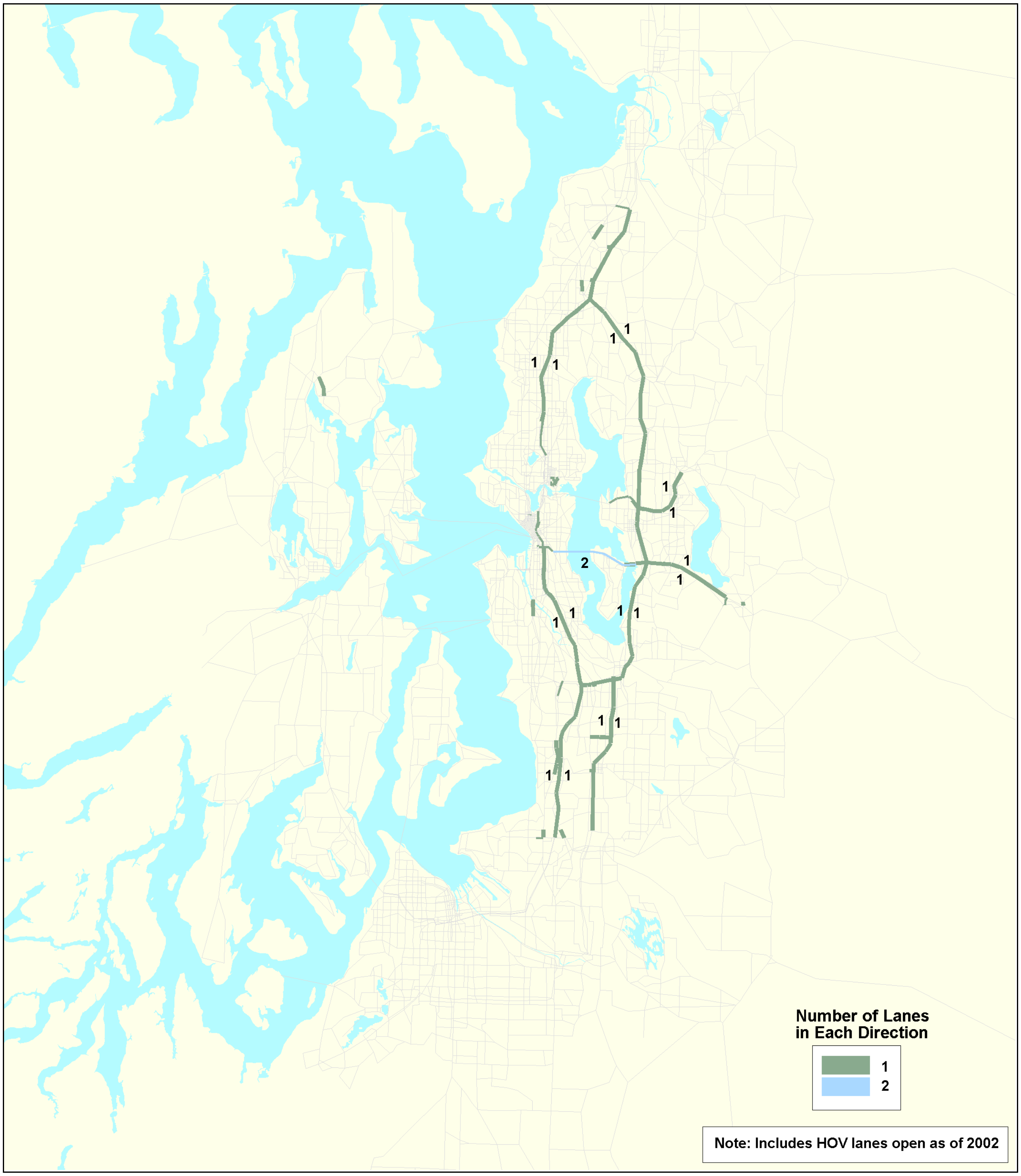
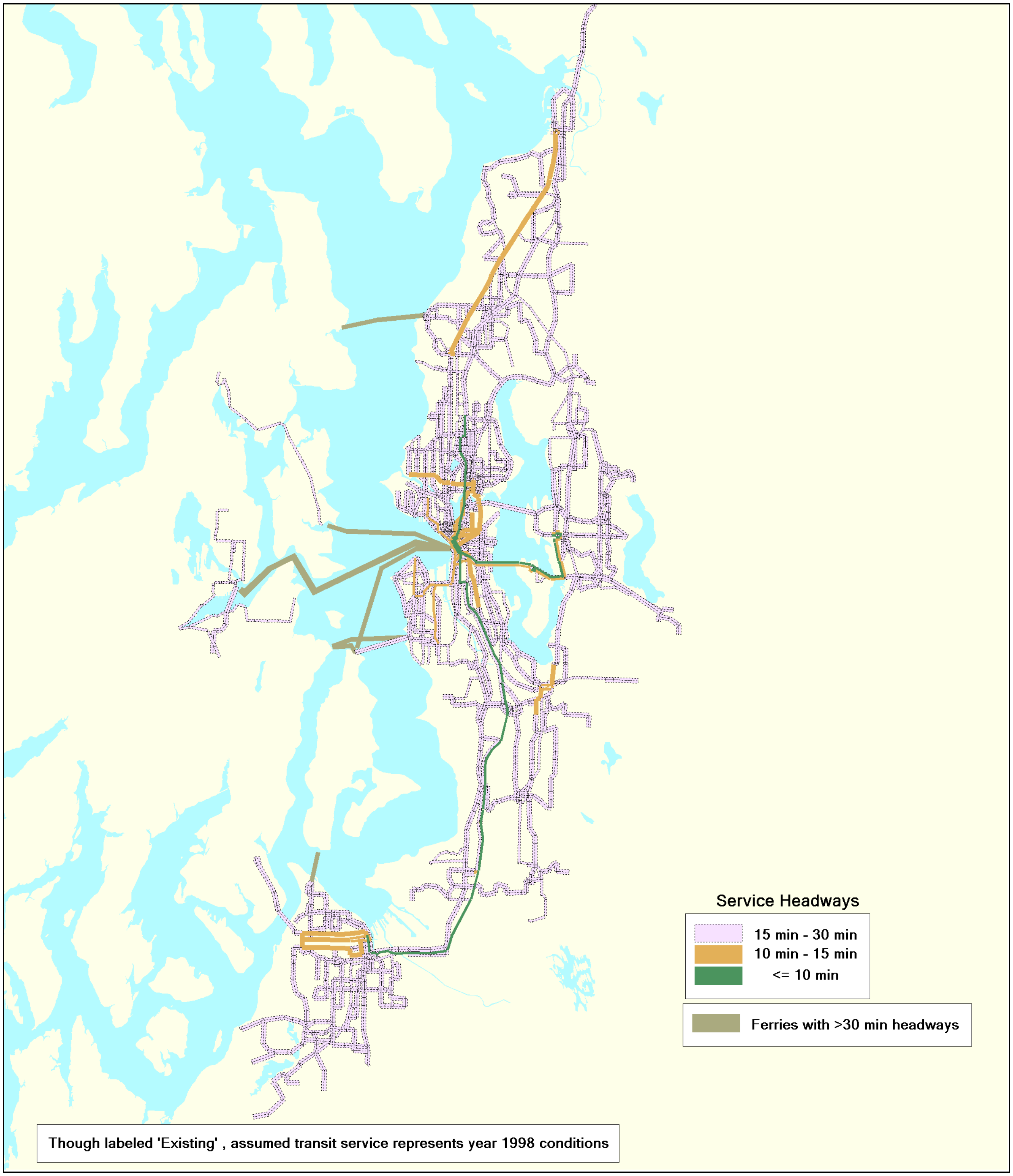


Figure 2-12: Transit Service Assumed for the Existing Condition Scenario



2025 Baseline Scenario

The 2025 Baseline Scenario provides a frame of reference for examining the various congestion relief scenarios. The transportation facilities in the 2025 Baseline Scenario include existing facilities and committed projects prior to 2005 as identified by WSDOT, regional providers, and local agencies.

Figure 2-13 and Figure 2-14 show the assumed highway and transit facilities added for the 2025 Baseline Scenario. Table 2-3 summarizes the major regional highway and transit facilities and services.

Highway improvements focus on the projects funded by the 2003 Nickel package. Transit improvements include the completion of Sound Transit Phase I, the Seattle Monorail Project (SMP) Green Line, and expansion of bus service levels. The 2025 Baseline Scenario assumes 7.5 million annual bus equivalent revenue hours, an increase of 3.6 million (92%) over existing conditions. All other future scenarios include the transportation facilities included in the 2025 Baseline Scenario.

Growth in Transit Service from Existing to 2025 Baseline

The CRA 2025 Baseline Scenario assumed an increase in transit service (as measured by vehicle hours) of approximately 90% compared to our base year for transit (1998). This growth assumes that transit operators in the Puget Sound area will provide additional service as their revenues grow over the next two decades. A 90% growth from 1998 to 2025 averages a 2.4% per year annual growth. As points of comparison, King County Metro vehicle hours grew about 20% from 1996 to 2003, a 2.6% per year annual growth. Pierce Transit vehicle hours grew about 41% from 1996 to 2003, a 5.0% per year annual growth. Community Transit vehicle hours grew about 49% from 1996 to 2002, a 6.8% per year annual growth.

Light rail, commuter rail, and monorail service are new transit facilities assumed to be in the 2025 Baseline Scenario that are not included in the existing transit network and account for 2.0 million additional annual bus equivalent revenue hours. The growth in service for buses alone would be approximately 1.6 million annual revenue hours, or an increase of 41%.

Table 2-3: Projects Included in the 2025 Baseline Scenario

Transit Projects: **Jurisdiction**	**Project**
Seattle/Tacoma	Sound Transit Central Link Light Rail (Phase 1) between S. 200th Street and
Tacoma/Seattle/Everett	Sound Transit commuter rail expansion between Lakewood and Everett
Region-wide	Sound Transit Regional Express bus service expansion
Seattle	Seattle Monorail Project: Green Line from West Seattle to Ballard
Roadway Projects: **Jurisdiction**	**Project**
Pierce	SR 7: Safety and access management from SR 507 to SR 512
Pierce	SR 16: HOV Improvements from Olympic View Dr. to Union Ave.
Pierce	I-5: HOV lanes from Port of Tacoma Rd. to King/Pierce Co. Line
Pierce	SR 410: Additional lanes from 214th to 234th
King	I-405: Additional lanes & interchange improvements from I-5 (Tukwila) to SR 522
King	I-5: NB auxiliary lane from NE 175th St. to NE 205th St.
King	I-90: Two-way transit and HOV from Bellevue Way to I-5
King	SR 161: Widen to five lanes from Jovita Blvd to S. 360th St.
King	SR 167: HOV from 15th St. SW to 15th St. NW
King	SR 522: UW Campus Access (Bothell)
King	I-5: Stage 4 HOV from Pierce County Line to S 320th
King	SR 520: HOV lanes from W Lake Sammamish Pkwy to SR 202
King	SR 99: N Corridor Transit/HOV Lanes on Aurora Ave.
Snohomish	SR 9: Additional lanes from SR 522 to 176th St. SE
Snohomish	SR 527: Additional lanes from 132nd SE to 112th SE
Snohomish	I-5: HOV lanes from SR 526 to US 2
Snohomish	SR 522: Four-lane widening from Snohomish River to US 2
Snohomish	SR 525: Additional lanes from SR 99 to Paine Field

Figure 2-13: GP and HOV Lanes added to Existing in the 2025 Baseline Scenario

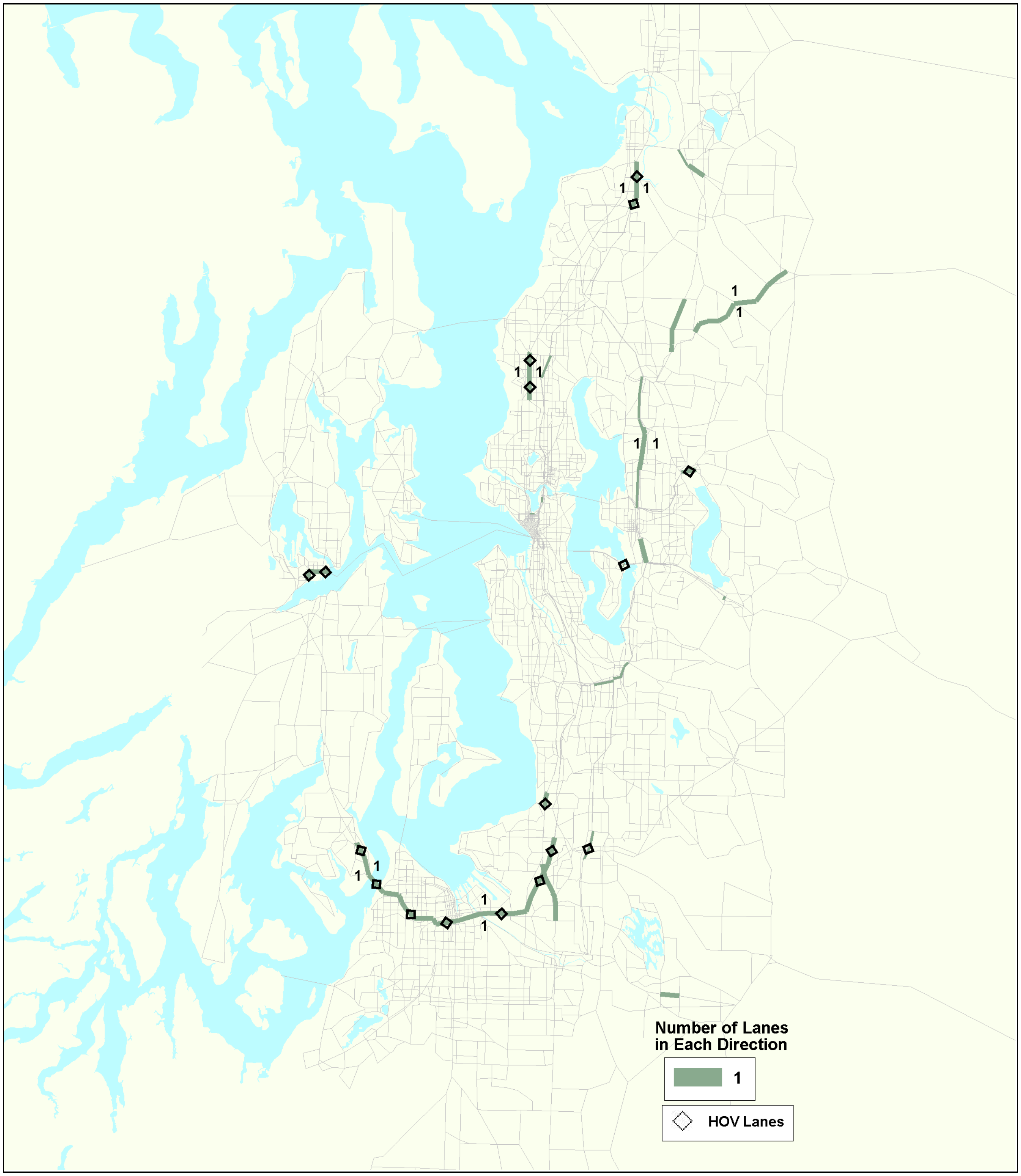
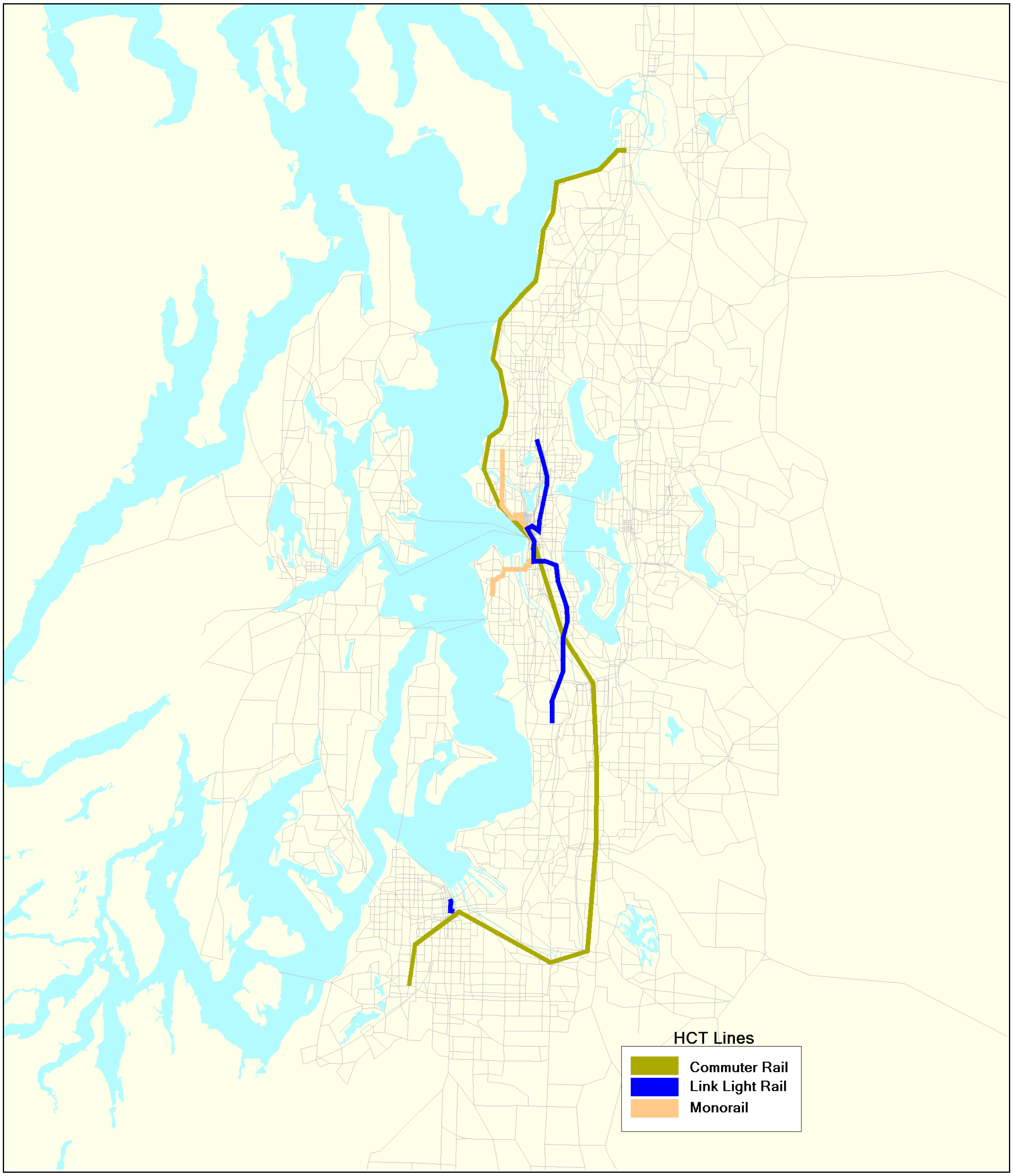


Figure 2-14: High Capacity Transit in the 2025 Baseline Scenario



Unconstrained Demand Scenarios

The starting point for the Congestion Relief Analysis was the unconstrained demand for travel in the central Puget Sound region. This point of reference helps to define where people, if given no congestion on existing facilities, would like to travel. Two different forecasts were tested to meet this demand; one based on free-flow speeds on the highway network and the other based on a ubiquitous transit network.

Unconstrained Highway Demand Analysis

The Unconstrained Highway Demand Analysis assumed that travelers could make any trip anytime within the region without delay. The forecasts were run using the 2025 Baseline highway network without any capacity constraints. The redistributed trips were assigned to the regional roadway network to show the desired paths and potential travel demand.

Figure 2-15 shows model predicted unconstrained demand and desired routes in the central Puget Sound region. The left-side map shows the large increase in vehicle trips that would take place on major freeways, state highways, and principal arterial routes. On the regional freeway system, the volumes would essentially be double the existing volumes. The right-side map shows the corresponding decrease in volumes on many of the local streets and arterials, as the trips would be drawn to higher speed facilities.

Using the information from Figure 2-15, the unconstrained highway demand was then translated into an equivalent number of highway lanes that would be needed to meet this theoretical demand. Figure 2-16 illustrates the model results using this technique. Most freeway corridors would require several additional lanes to carry the 'unconstrained demand'. Conversely, volumes on most local arterial routes would decrease, indicating that local routes would be underutilized if capacity were abundant on the major state highways.

As an example, the following additional lanes (two directions combined) would be required to meet this demand in the PM peak period:

- I-5 thru Seattle: 10-14 new lanes
- I-405 thru Bellevue: 12-14 new lanes
- I-5 to Everett: 8-10 new lanes
- SR 167 thru Kent/Renton: 4-8 new lanes
- I-5 thru Tacoma: 8-10 new lanes
- SR 520 cross lake: 4-6 new lanes

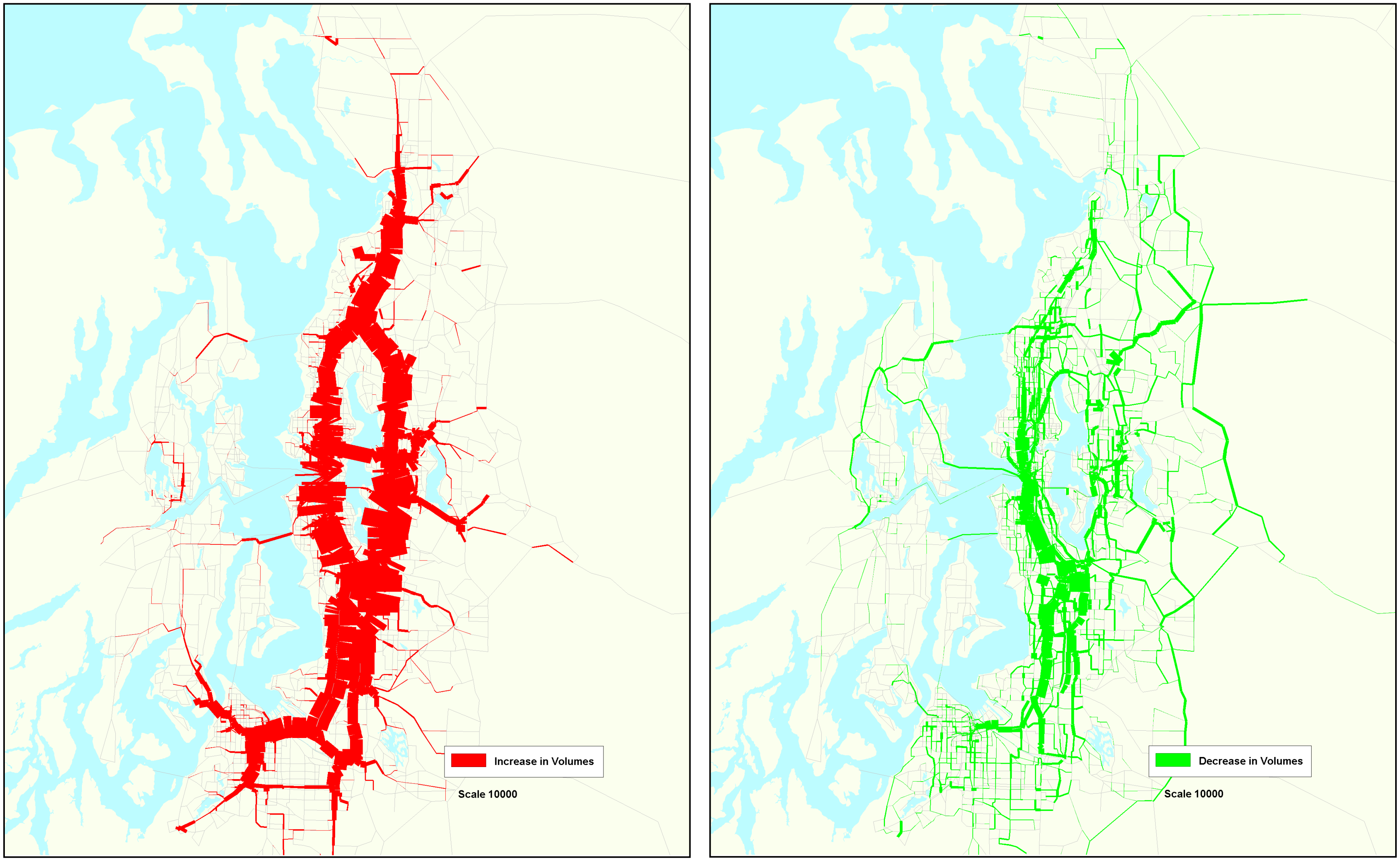
These results were used to help shape the Highway Focus Scenario and to compare certain key performance data.

Unconstrained Transit Demand Analysis

The Unconstrained Transit Demand Analysis produced forecasts of transit demand assuming that point-to-point transit service would be available everywhere in the region. The resulting demand was then loaded onto the 2025 Baseline highway network to graphically illustrate the desired transit travel corridors.

Travelers were assumed to have direct walk access to transit (within 2.5 minutes) with a direct transit connection available to every destination within the region with wait times of 5 minutes in the peak and 7.5 minutes in the off peak. The transit speed was assumed to be a constant 18 mph for all trips (12 mph is today's average) and transit fares were assumed to be consistent with today.

Figure 2-15: Changes in Daily Vehicle Volumes in the Unconstrained Highway Demand Analysis (vs. 2025 Baseline)



If highway travel were unconstrained…	
People would focus their travel on the freeways and major highways because trip times are shorter	As a result, volumes would decrease on many local streets and arterials

Figure 2-16: Additional Lanes Needed to Meet Unconstrained Highway Demand

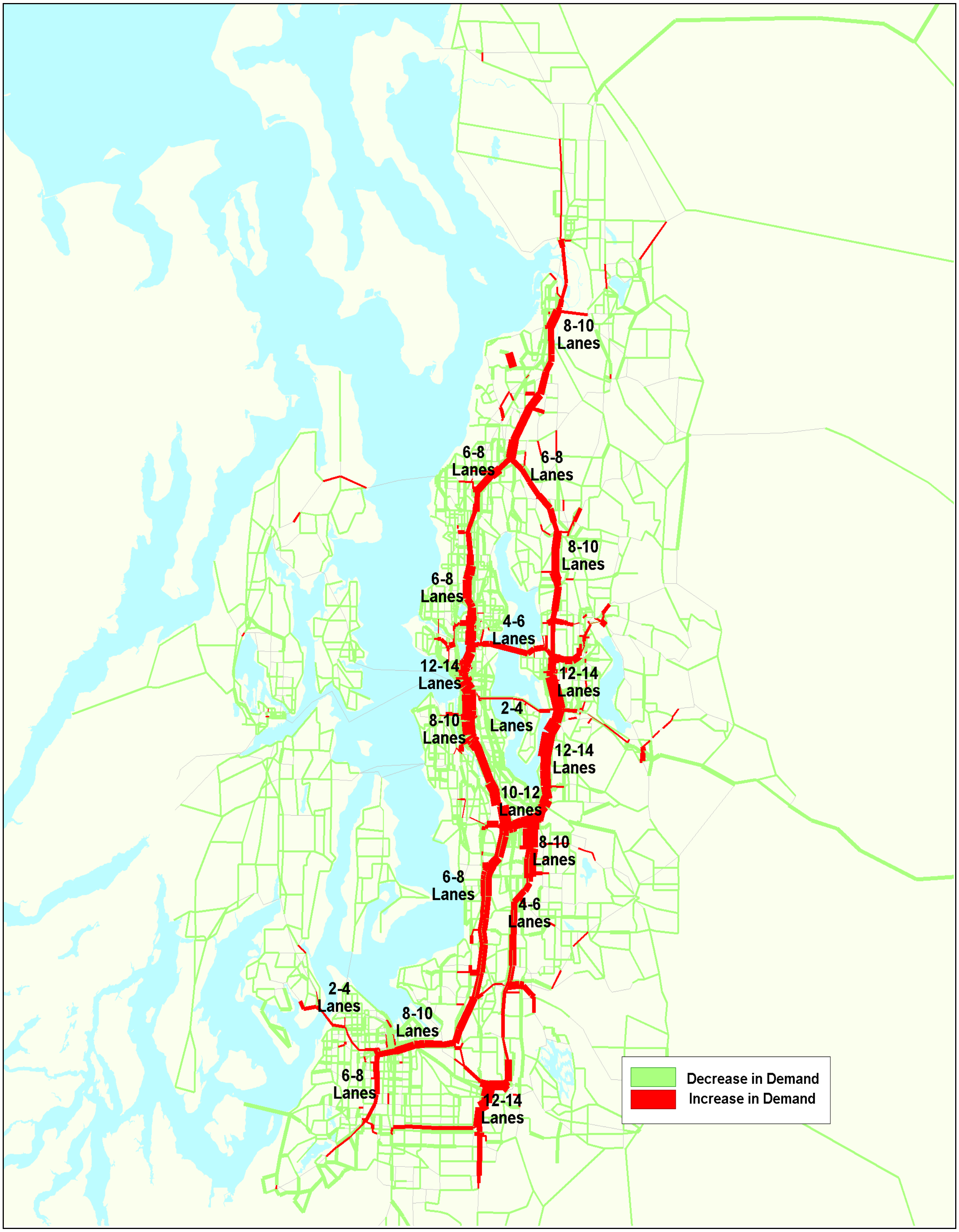
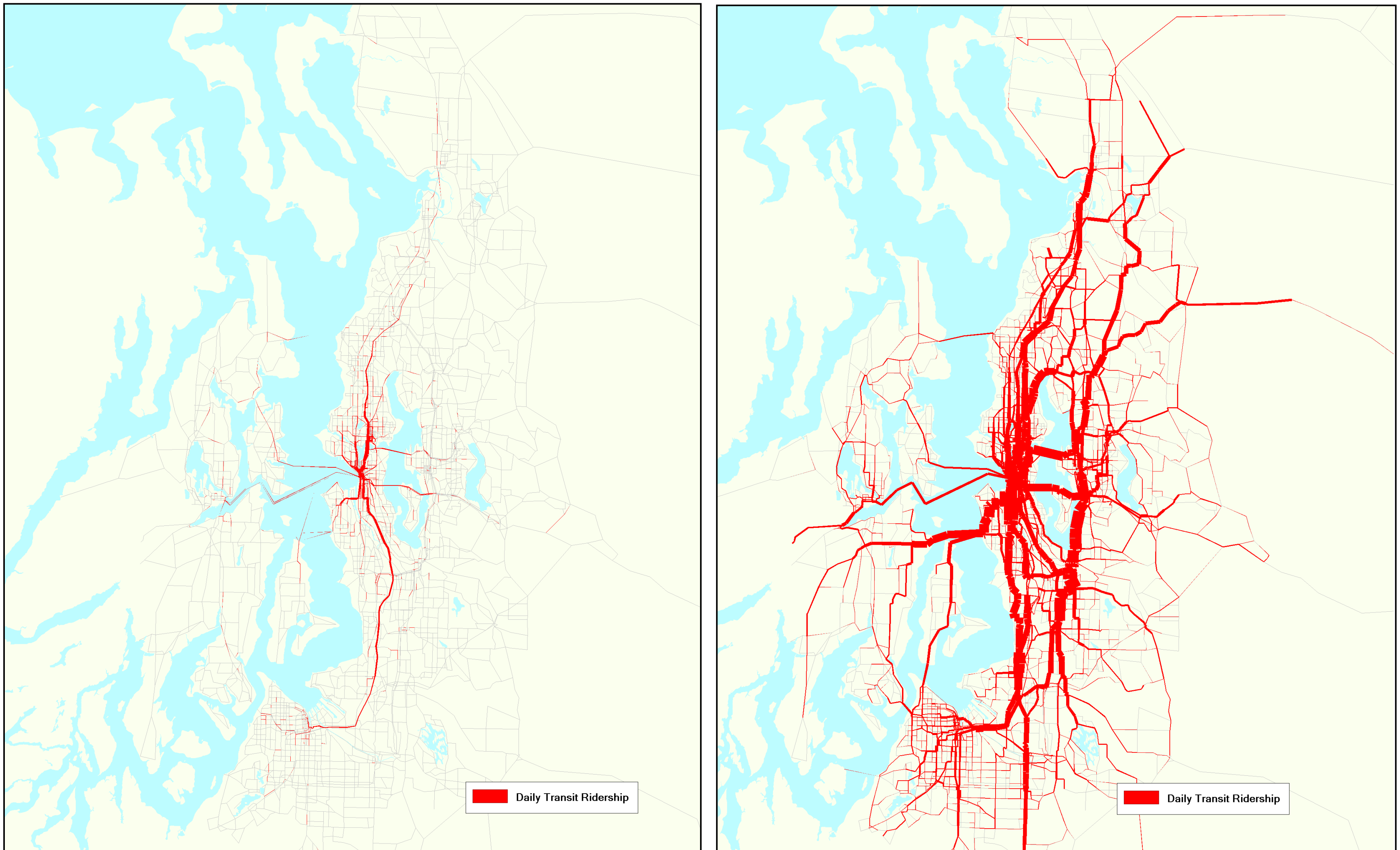


Figure 2-17 shows the results of the transit-unconstrained ridership forecasts within the region compared with existing transit ridership. The ubiquitous transit system would result in an increase in daily ridership in the central Puget Sound region from 314,000 today to as high as 3.8 million in 2025 (more than a tenfold increase). At the corridor level, using I-5 as an example, the daily transit ridership from north of Seattle to Downtown Seattle would increase from 50,000 today to 108,000 in 2025.

Using this information, the study team identified corridors with the highest transit demand as possible high-capacity transit (HCT) routes. Corridors with moderate to high demand were identified as candidates for expanded bus service. These results were used to help shape the Transit Focus Scenario and the mixed scenarios.

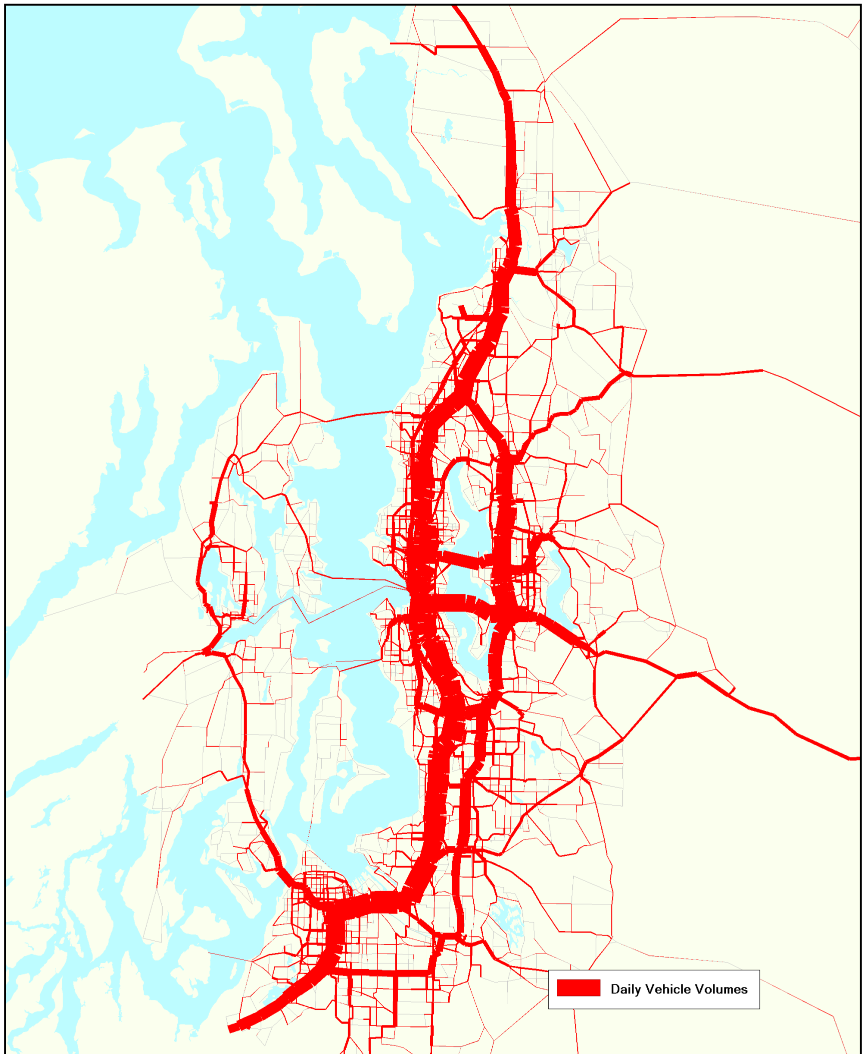
It should be noted that, according to the model, even with this ubiquitous transit system, highway travel would continue to increase. Figure 2-18 compares the daily vehicle travel on the network today with the projected amount of vehicle trips in 2025 under the ubiquitous transit scenario. The model predicted that there would still be enough vehicle demand on the regional highway system to cause almost 385,000 hours of delay per day compared to 285,000 today. This is 100,000 hours per day more than today's estimated delay.

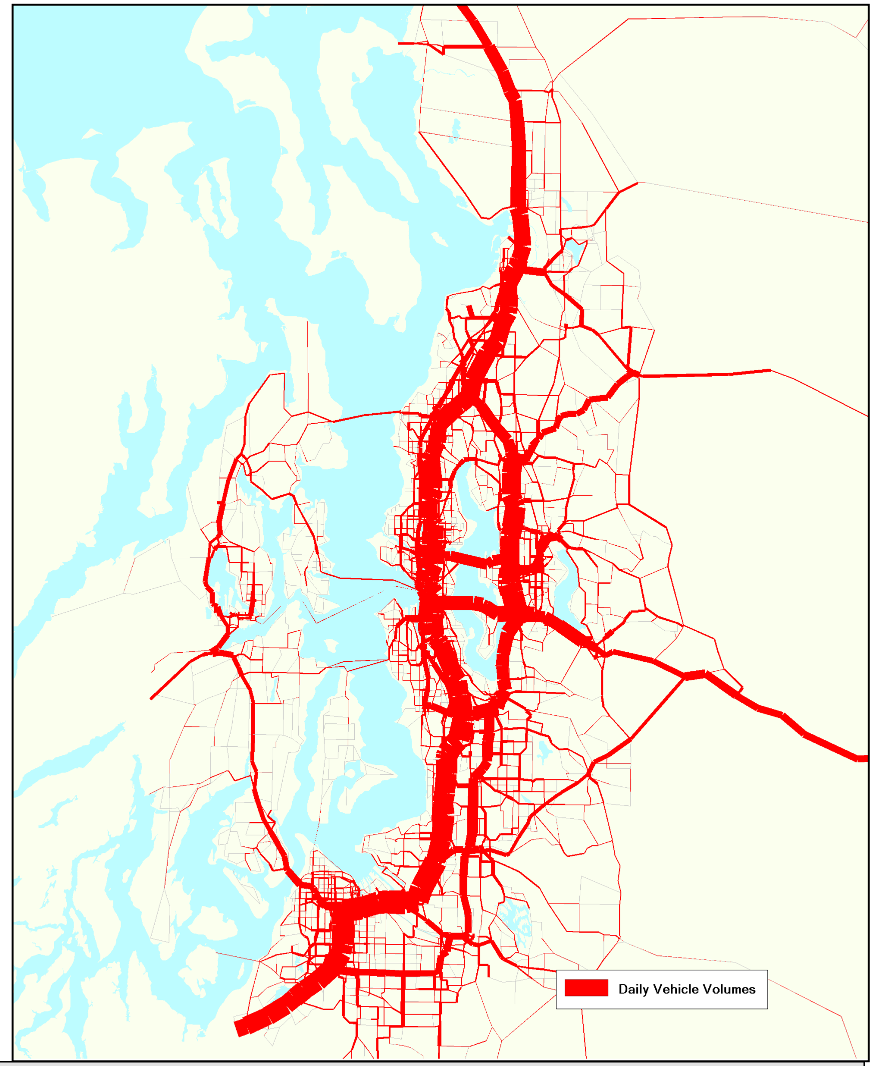
Figure 2-17: Comparison of Transit Ridership for Existing and Unconstrained Transit Demand



What happens to transit demand?	
Today there are 314,000 daily transit riders in the region	In 2025, an unconstrained transit system attracts more than ten times as many riders (up to 3.8 million per day)

Figure 2-18: Comparison of Vehicle Volumes for Existing and Unconstrained Transit Demand





Growth in vehicle travel will result in an additional 100,000 hours of daily delay, even with an unconstrained transit system	
Daily vehicle trips today in the region	Daily vehicle trips in 2025 with unconstrained transit

Highway Focus Scenario

The Highway Focus Scenario provided highway capacity intended to meet much of the unconstrained travel demand. Its purpose was to examine whether congestion could be alleviated through an aggressive road-building program. The specific capacity additions were identified based on the results of the 2025 Baseline and Unconstrained Highway Demand model runs and were inclusive of the highway projects identified in the PSRC's Metropolitan Transportation Plan (MTP).

Region wide the Highway Focus Scenario included 1,230 more freeway and 730 more arterial lane miles than the 2025 Baseline Scenario. This represents a 7% growth in arterial lane miles, a 50% growth in freeway lane miles, and a 16% growth in total lane miles (freeway and arterial lanes combined). Almost three-quarters of the lane miles were added directly within the region's urban growth area, while most of the other lane additions would serve connecting routes between adjacent portions of the urban growth area. Table 2-4 summarizes the lane miles added in the Highway Focus Scenario.

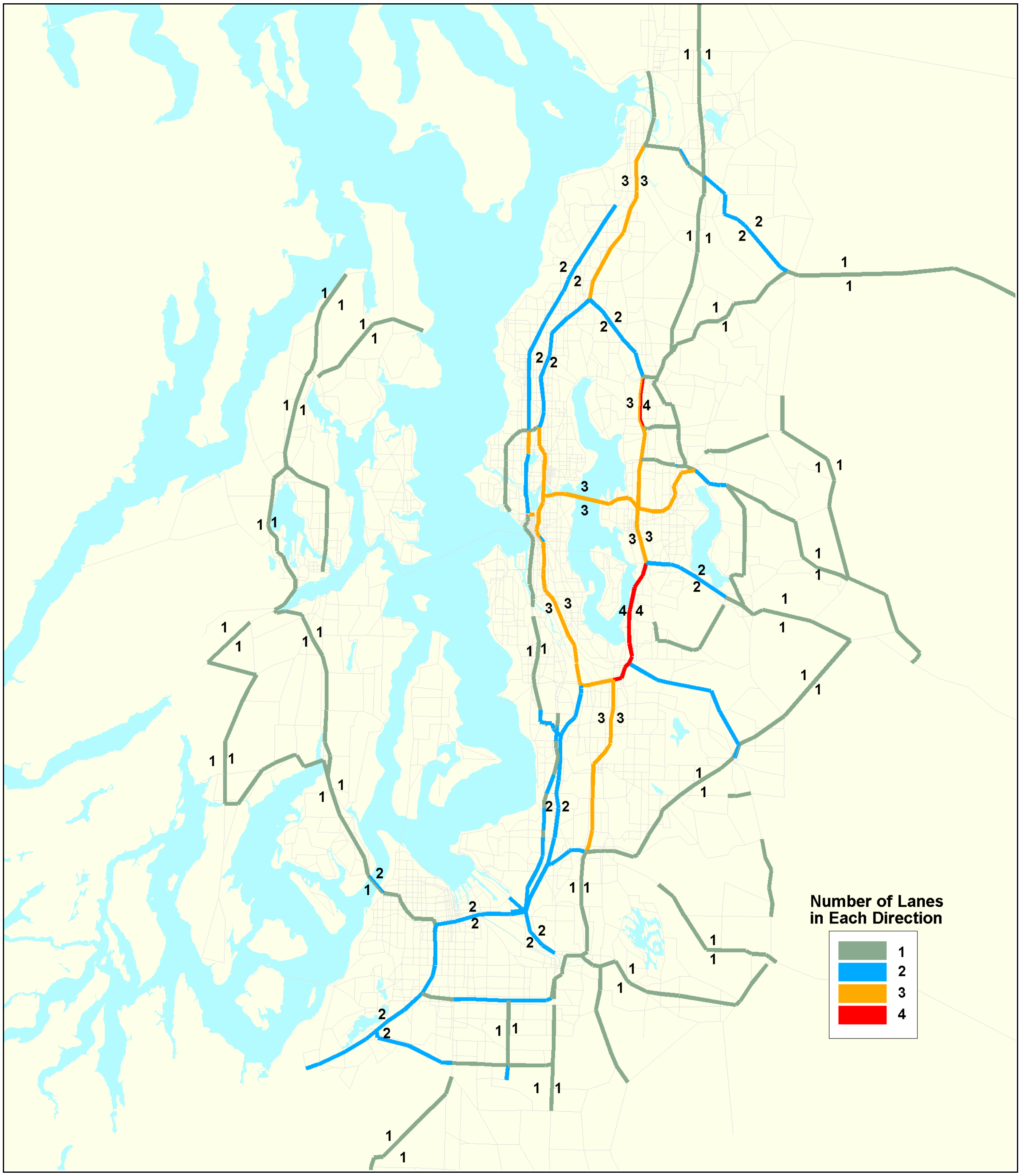
Table 2-4: Highway Lane Miles by Scenario

Scenario	Lane Miles in Region			
	Freeways / Expressways	*Arterials*	*Total*	*Percent within UGA*
Existing	2,320	9,940	12,260	n/a
2025 Baseline	2,360	9,980	12,340	n/a
	Lane Miles Added by Scenario (Compared to 2025 Baseline)			
Highway Focus	+1,230 (+52%)	+730 (+7%)	+1,960 (+16%)	74%
Transit Focus	+0	+0	+0	n/a
Pricing Focus	+0	+0	+0	n/a
Mixed: Highway and Transit Intensive	+1,010 (+43%)	+390 (+39%)	+1,400 (+11%)	84%
Mixed: Highway Emphasis	+1,010 (+43%)	+390 (+39%)	+1,400 (+11%)	84%
Mixed: Transit Emphasis (and with Pricing)	+610 (+26%)	+230 (+23%)	+840 (+7%)	88%

Figure 2-19 shows the number of general-purpose (GP) lanes added in the Highway Focus Scenario. The following are some specific locations where lanes were added:

- I-5 through Pierce, King and Snohomish Counties: added two to three lanes each direction;
- I-405: added two to four lanes each direction;
- SR 520 from Seattle to Redmond: added three lanes each direction;
- I-90 from Bellevue to Issaquah: added two lanes each direction;
- SR 167: added one to three lanes each direction; and
- SR 99 from Everett to Tacoma: added two lanes each direction.

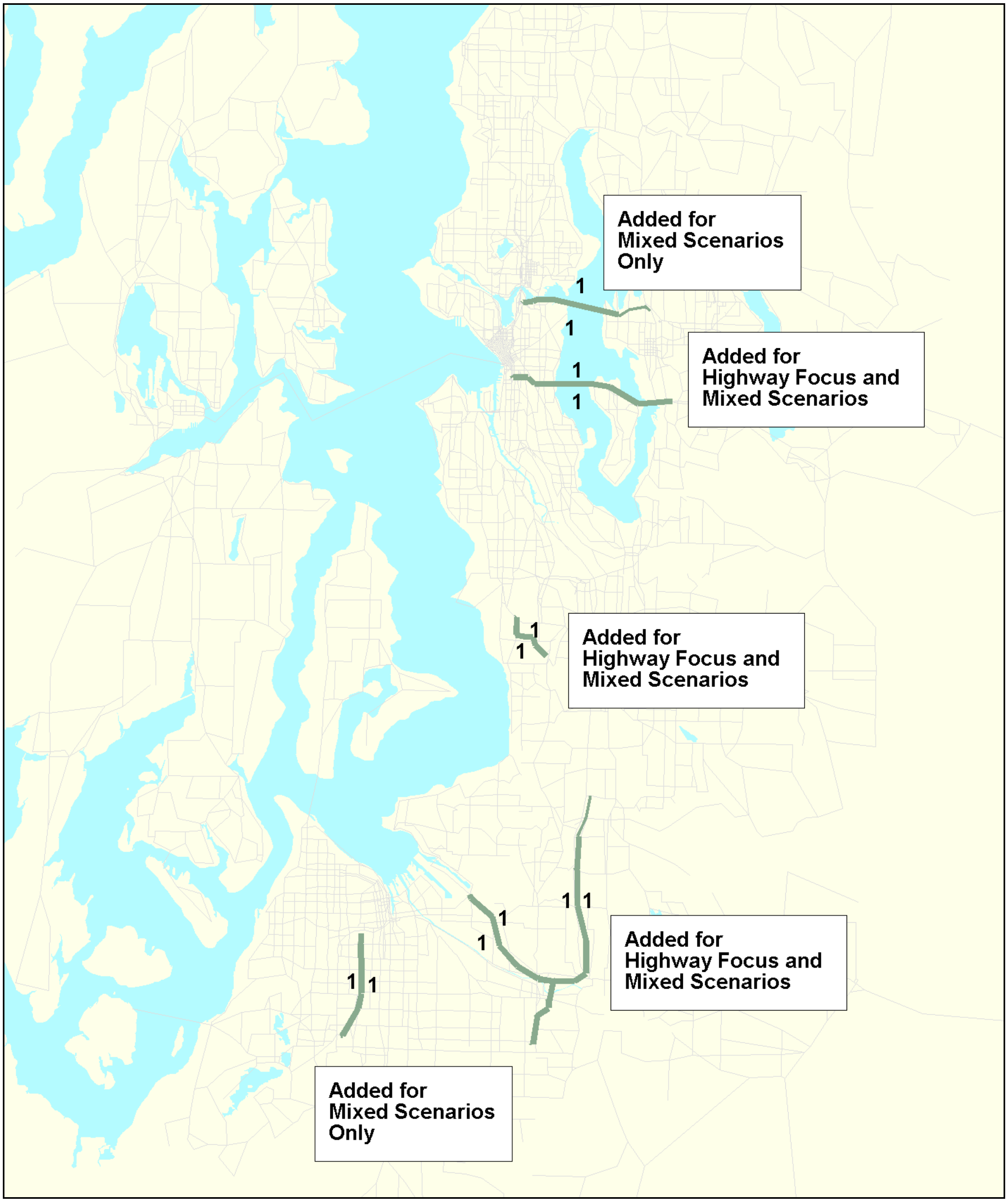
Figure 2-19: GP Lanes Added to 2025 Baseline in the Highway Focus Scenario



Within downtown Seattle, to minimize impacts to existing buildings, a six-lane tunnel was assumed to run from Spokane Street in the south to Northgate in the north. Along SR 16, a lane was added across the Tacoma Narrows Bridge by restriping the existing (and new) bridge.

In the Highway Focus Scenario, HOV lanes were added to I-90 across Lake Washington, the SR 509 extension, and along the southern portion of SR 167. These lanes are shown in Figure 2-20.

Figure 2-20: HOV Lanes Added to 2025 Baseline in the Highway Focus and Mixed Scenarios



Transit Focus Scenario

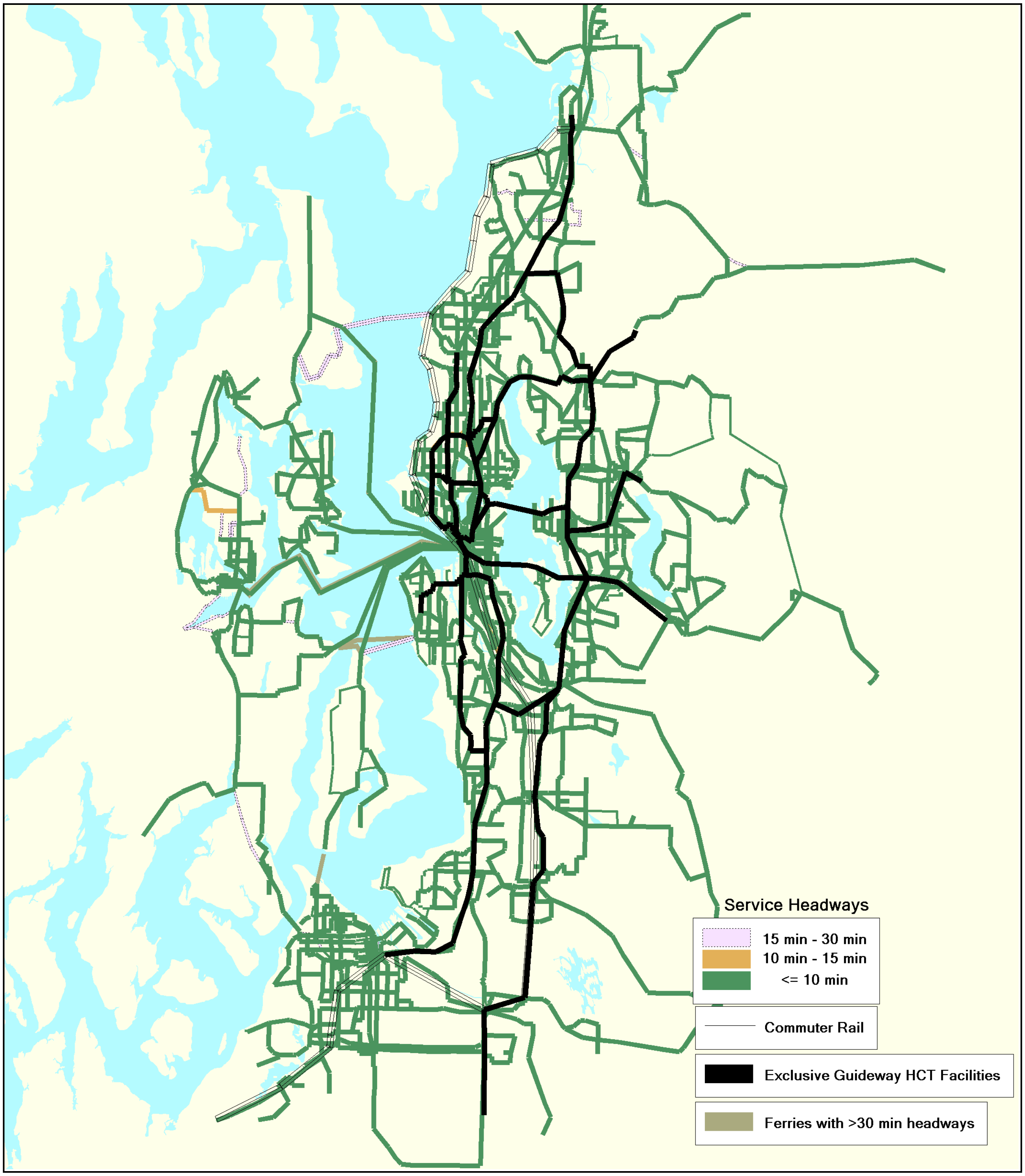
The Transit Focus Scenario included an extensive regional transit system designed to correspond to the major travel corridors identified from the Unconstrained Transit Demand Analysis. Its purpose was to examine whether enough people would utilize a highly convenient transit system instead of driving their cars, with the result being less congestion. With this scenario, the supply of transit service would be approximately 15.2 million annual bus equivalent revenue hours in the central Puget Sound region, which is approximately double the number of annual bus equivalent revenue hours in the 2025 Baseline Scenario, and nearly four-times the Existing Condition. Transit service in this scenario is shown in Figure 2-21.

The details of this scenario were developed in coordination with PSRC, King County Metro, Sound Transit, and Washington State Ferries. HCT lines included in the PSRC's MTP and the Sound Transit Long-Range Vision were used as the base for building the HCT portion of the Transit Focus Scenario network. HCT segments were also added in other high-volume locations as identified in the unconstrained runs. The HCT lines were assumed to operate all day, in both directions with ten-minute peak headways.

Additionally, bus service was expanded for almost all bus routes, although several Sound Transit Regional Express routes were removed and replaced by HCT lines. Passenger ferry service was expanded between Downtown Seattle and Bainbridge, Bremerton, Kingston, Southworth, and Vashon.

Park-and-ride lots were included at most HCT stations and regional express bus hubs outside the urban core areas. A total of 57 new lots were assumed, containing on average 300 parking stalls each. This amounts to the addition of approximately 17,000 parking stalls. Direct access ramps to/from park-and-ride lots were not assumed for this study.

Figure 2-21: Transit Service Included in the Transit Focus Scenario



Pricing Focus Scenario

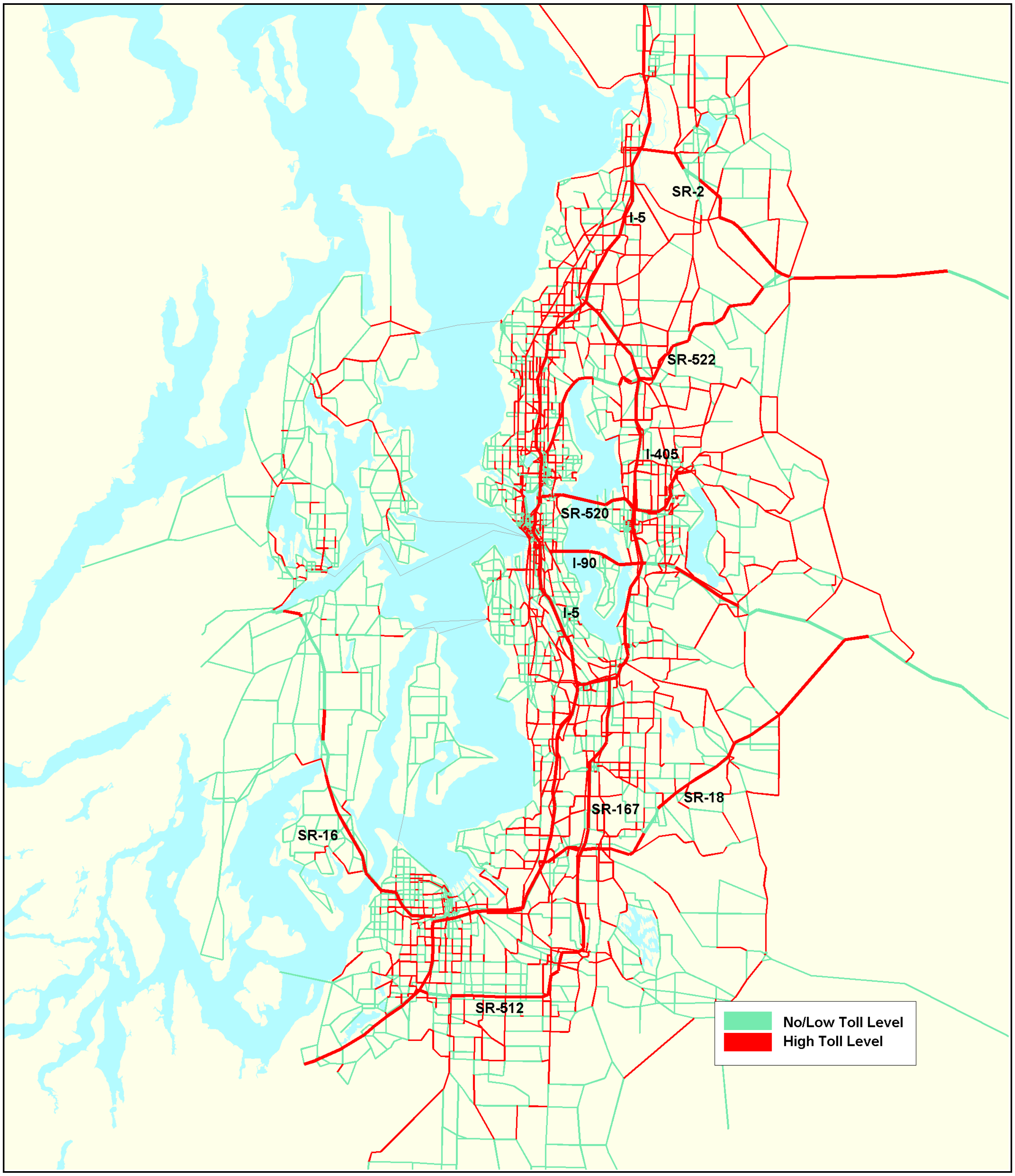
The Pricing Focus Scenario examined a region-wide value pricing program. Its purpose was to evaluate the extent to which delay could be reduced on the existing transportation network by introducing value pricing in the form of tolls. This scenario assumed the same roadway and transit infrastructure as the 2025 Baseline Scenario, but it assumed that all freeways and arterials in the central Puget Sound region would be variably tolled according to demand and capacity conditions.

The Pricing Focus Scenario's underlying objective was to manage travel demand through tolling in an effort to make more efficient use of existing capacity. Value pricing can achieve this by encouraging some users to alter their travel behavior (particularly during congested times) by using other routes, shifting to transit or carpools, changing their destinations (making shorter trips), and even potentially changing their time of travel or eliminating some trips.

The Pricing Focus Scenario was developed to address many of these travel demand features. It assumed that all elements of the regional roadway network, with the exception of HOV or transit-only lanes, would be tolled on a per-mile basis. Vehicles operating in HOV or transit-only lanes would not be subject to the tolls. Toll rates for each roadway segment and travel direction would be determined by the demand and capacity relationships of the segment at different times of day and users' willingness to pay for delay reduction. Expressed in current dollars, tolls would vary from zero at times of low demand (no congestion), and would rise exponentially with increasing demand/delay to 50 cents per mile when roadways are highly congested and demand meets or exceeds capacity. The regional model does not account for any time-of-day trip shifting or elimination of trips that might be associated with a value pricing strategy.

To illustrate the Pricing Focus Scenario, Figure 2-22 shows a map of the central Puget Sound region with roadway facilities marked with either 'high' or 'low' toll level. Using the previously described value pricing methodology, facilities with a high tolling level are generally those that would have relatively high levels of traffic congestion. Not surprisingly, these roads include most of the regional freeways, state highways, and major arterials. On these facilities, a toll rate would need to be set sufficient to cause route or mode shifts and a subsequent reduction in the congestion levels. Conversely, facilities denoted with a low toll level are those that would have relatively low congestion levels prior to the introduction of value pricing. Most of the lower classification regional and local highways would fall into this category.

Figure 2-22: Pricing Focus Scenario – Potential Toll Levels During the PM Peak Period



Mixed Scenario – Highway and Transit Intensive

The Highway and Transit Intensive Mixed Scenario combined the most productive parts of the Highway and Transit Focus Scenarios. Its purpose was to test the extent to which congestion could be relieved by investing aggressively in both highways and transit improvements. This scenario added 1,010 freeway and 390 arterial lane miles to the 2025 Baseline Scenario, or approximately 18% fewer freeway lane miles and 57% fewer arterial lane miles than the Highway Focus Scenario. Almost 85% of the lane miles were added directly within the region's urban growth area, since several of the outlying road segment additions were removed in this scenario. Table 2-4 on page 2-25 summarizes the lane miles added in the Highway and Transit Intensive Mixed Scenario.

In comparison with the Highway Focus Scenario, lanes were reduced in each direction on the following freeways: SR 520 (reduced from a three-lane to a one-lane addition across the bridge, and reduced to a two-lane addition east of I-405); SR 512 (reduced from a two-lane to a one-lane addition); I-5 through downtown Seattle (reduced from a three-lane to a two-lane addition), and I-405 from Bellevue to Renton (reduced from a four-lane to a three-lane addition). These lanes were reduced after evaluation of the performance results of the Highway Focus Scenario and the identification of segments in which fewer lanes might produce comparable results. Through downtown Seattle, I-5 was still configured in a tunnel alignment with two lanes in each direction. Several arterial lanes from the Highway Focus Scenario were removed in portions of the region where congestion levels were not too severe.

The Highway and Transit Intensive Mixed Scenario included a high level of transit investment, although not as much as the Transit Focus Scenario. Upon examining the Transit Focus Scenario's ridership forecasts, the less-productive HCT facilities were identified and replaced with buses operating on HOV lanes at 15-minute peak period headways. When compared to the Transit Focus Scenario, headways were increased (frequency reduced) on those routes operating less than half full at peak load point. This scenario would provide 12.5 million annual bus equivalent revenue hours, or a 67% increase over the 2025 Baseline Scenario.

Figure 2-23 shows the number of GP lanes included in the Highway and Transit Intensive Mixed Scenario. HOV lanes were also added to several facilities that are part of the State's core HOV system, as shown in Figure 2-20 on page 2-27. Transit service in this scenario is shown in Figure 2-24.

Figure 2-23: GP Lanes added to 2025 Baseline in the Highway Emphasis and Highway and Transit Intensive Mixed Scenarios

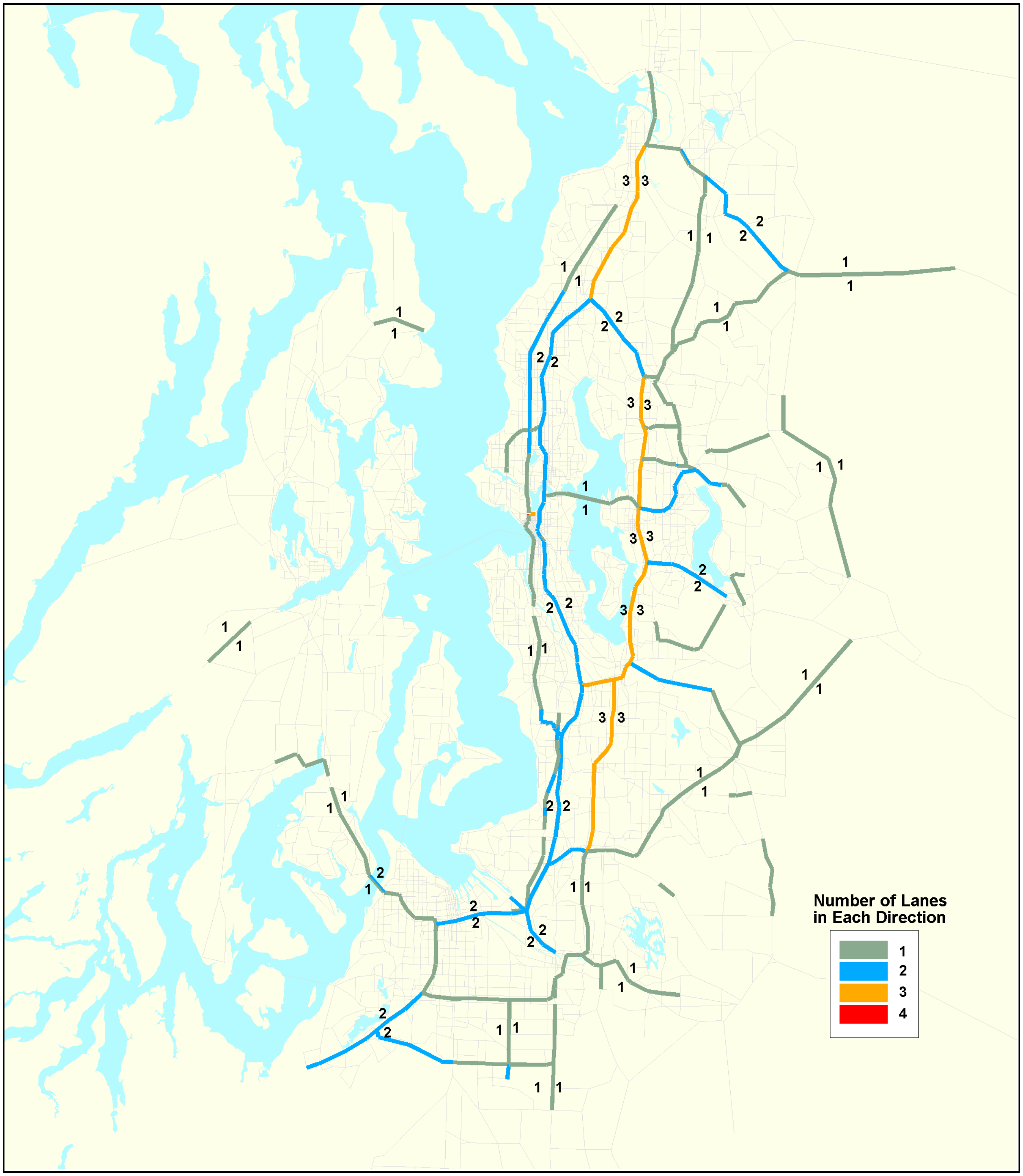
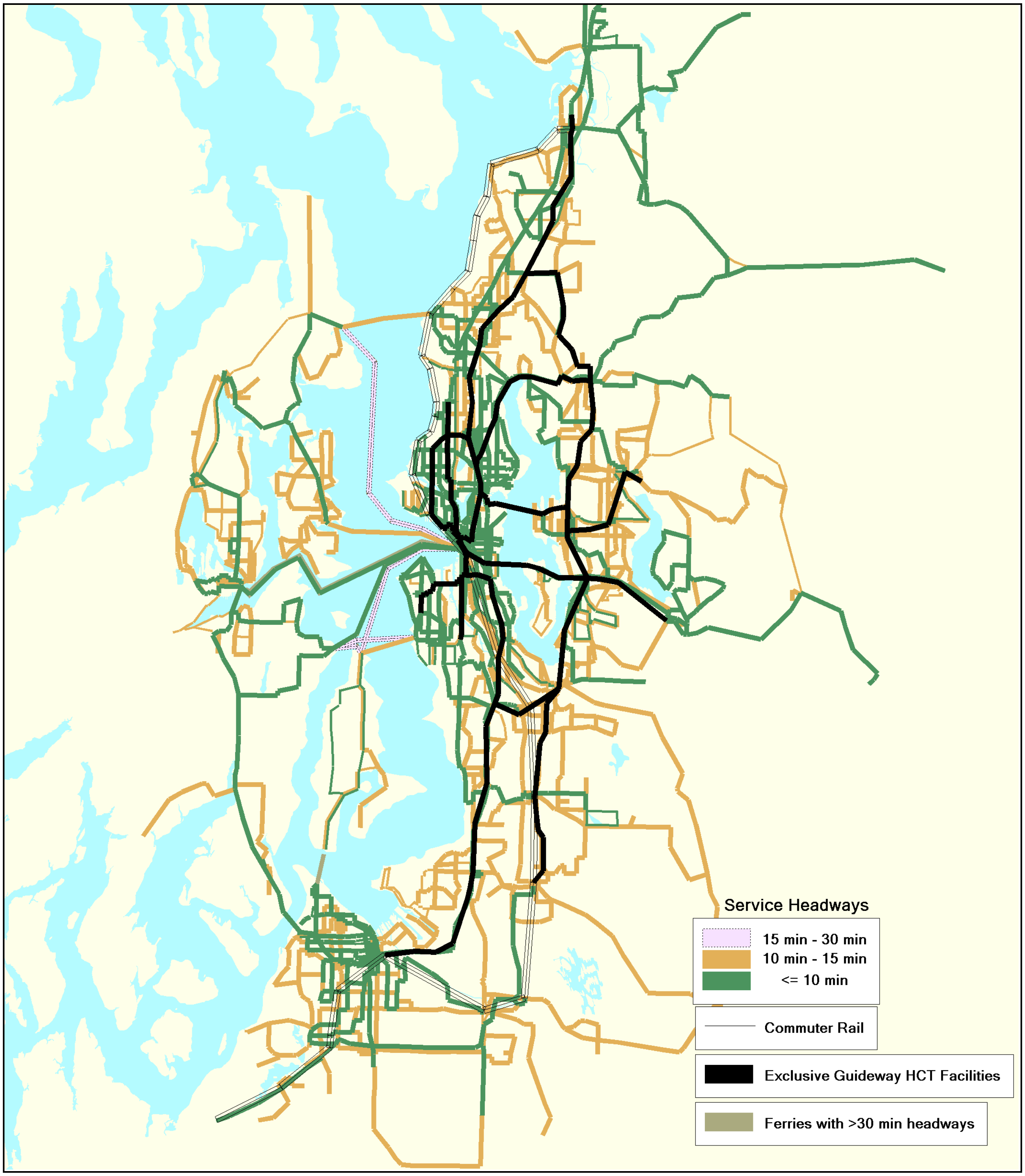


Figure 2-24: Transit Improvements in the Transit Emphasis and Highway and Transit Intensive Mixed Scenarios

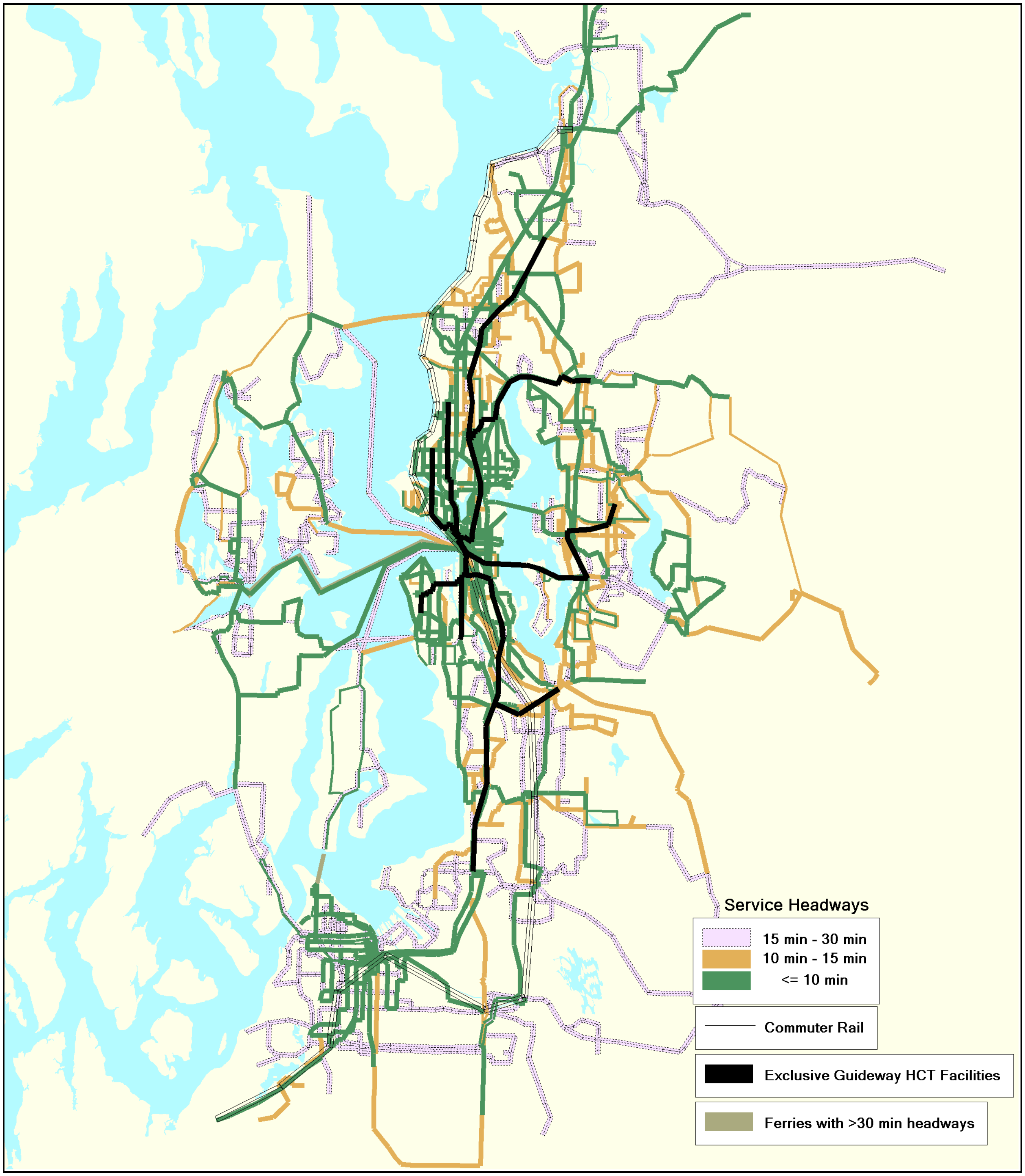


Mixed Scenario – Highway Emphasis

The Highway Emphasis Mixed Scenario had the same level of highway investment as described in the Highway and Transit Intensive Mixed Scenario, but it included a lower level of transit investment. Its purpose was to test the degree to which lowering the level of transit infrastructure and service affects congestion levels, while keeping the highway investment fixed. The GP lane additions are shown in Figure 2-23 on page 2-33 and the HOV lane additions are shown in Figure 2-20 on page 2-27.

The Highway Emphasis Mixed Scenario included improvements in transit service that go beyond those included in the 2025 Baseline Scenario, but are less than included in either the Transit Focus Scenario or the Highway and Transit Intensive Mixed Scenario (see Figure 2-25). In most cases, HCT was replaced with frequent bus service operating on HOV lanes. Most peak-period headways were less than or equal to 30 minutes. Compared to the Highway and Transit Intensive Mixed Scenario, headways were increased on those routes operating less than half full at the peak load point. Total transit service supplied would be approximately 11.0 million annual bus equivalent revenue hours, representing a 45% increase over the 2025 Baseline Scenario.

Figure 2-25: Transit Service Included in the Highway Emphasis Mixed Scenario



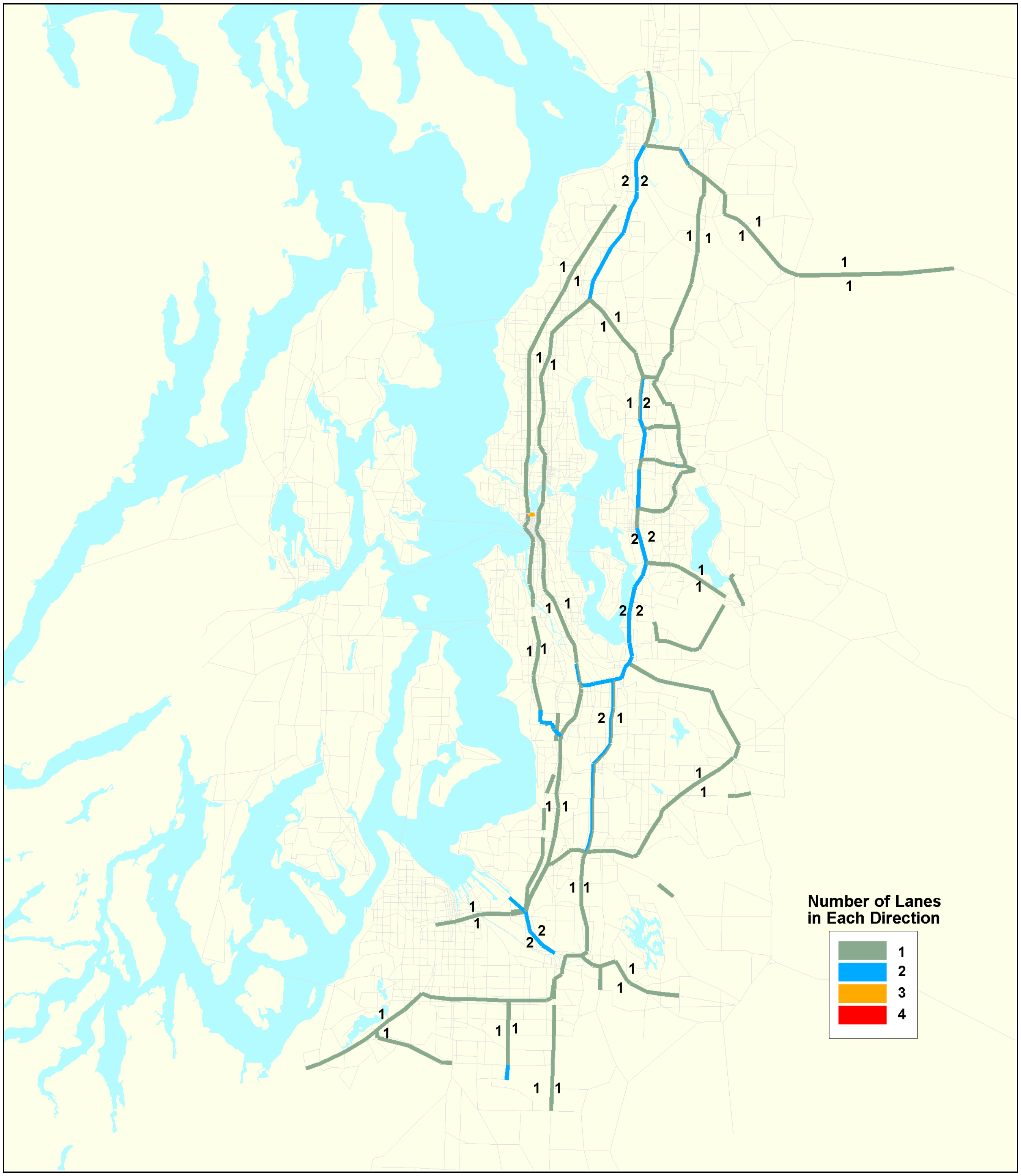
Mixed Scenario – Transit Emphasis

The Transit Emphasis Mixed Scenario included the same level of transit investment described for the Highway and Transit Intensive Mixed Scenario (Figure 2-24 on page 2-34), but it had a lower level of highway investment. Its purpose was to test the degree to which lowering the level of highway infrastructure affects congestion levels, while keeping the transit investment fixed.

This scenario included an additional 610 freeway and 230 arterial lane miles, as compared with the 2025 Baseline Scenario. The GP lanes added in this scenario are shown in Figure 2-26. HOV lanes were also added to several facilities that are part of the state's core HOV system, as shown in Figure 2-20 on page 2-27. Almost 90% of the lane miles were added directly within the region's urban growth area since most of the remaining outlying road segment additions were removed in this scenario. Table 2-4 on page 2-25 summarizes the lane miles added in the Transit Emphasis Mixed Scenario.

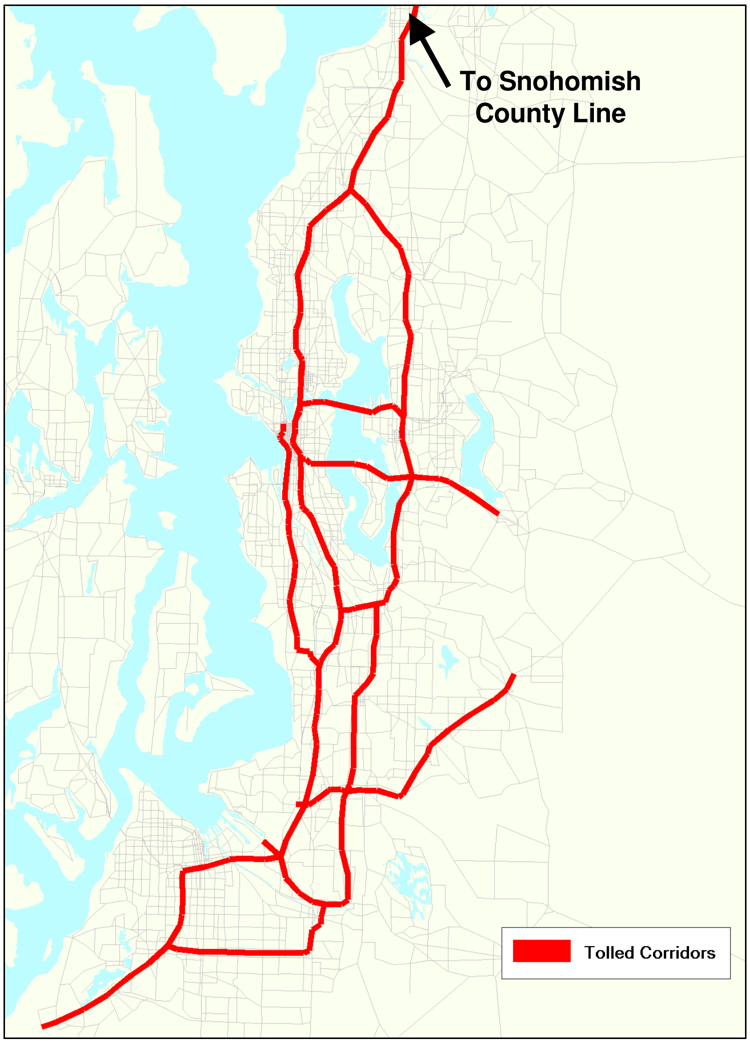
Specific freeway capacity additions included the following: I-5 (added one more lane through most of Pierce and King Counties and two lanes in Snohomish County); I-405 (added one to two lanes); SR 520 (added one lane); SR 167 (added one to two lanes). For this scenario, one GP lane was removed from most freeway corridors in the Highway and Transit Intensive Mixed Scenario, so that no facility had more than two added GP lanes in each direction. Through downtown Seattle, one additional travel lane was assumed along the existing roadway cross-section without construction of a tunnel facility. Overall, the highway investment represents approximately 40% of the lanes added in the Highway Focus Scenario.

Figure 2-26: GP Lanes Added to 2025 Baseline in the Transit Emphasis Mixed Scenario



Mixed Scenario – Transit Emphasis with Pricing

Figure 2-27: Tolled Corridors in the Transit Emphasis with Pricing Mixed Scenario



The Transit Emphasis with Pricing Mixed Scenario began with the same level of highway and transit investment as described under the Transit Emphasis Mixed Scenario. It then added value pricing on all freeways that contained at least one additional lane of freeway capacity, as shown in Figure 2-28[5]. The purpose of this scenario was to test whether selective value pricing of roadways could reduce congestion through the introduction of value pricing as a substitute for adding more roadway capacity. The scenario also tested the interaction of value pricing with a high level of transit investment.

The tolls paid by travelers on the highway system would vary by time of day and level of congestion.

The following table shows three examples that illustrate a typical toll that might apply during peak periods on several lengthy commuter routes:

Table 2-5: Sample Tolls for PM Peak Period Commutes

From	To	Miles	Toll Rate per Mile	Total Toll
Bellevue	Lynnwood	18.5	$0.20 - $0.25	$3.70 - $4.60
Seattle	Issaquah	13.9	$0.20 - $0.25	$3.20 - $3.60
Renton	Tacoma*	11.7	$0.30 - $0.40	$3.50 - $4.40

*Via SR 167 (tolls via I-5 would be twice as high)

[5] Tolling on SR 16 (Tacoma Narrows Bridge) was included in this Scenario as part of the 2025 Baseline assumption.

2.6 Model Results

Transportation Analysis

A series of transportation analysis metrics was developed to assess the comparative performance of the scenarios in terms of their effectiveness in addressing congestion. Table 2-6 lists the analysis metrics chosen to compare performance among the scenarios. The analysis included a mixture of system-level and corridor-specific metrics.

Table 2-6: Transportation Analysis Metrics

Analysis Metric	Definitions
Vehicle Hours of Delay	The amount of delay (per vehicle) experienced either daily or during the two-hour PM peak period.
Commercial Vehicle Hours of Delay	The amount of delay experienced by trucks either daily or during the two-hour PM peak period.
Vehicle Delay per Mile	The intensity of delay experienced by vehicles on the state highway system measured as total daily delay per mile.
Congested Hours per Day	The number of hours per day during which a corridor is congested in the peak direction of travel.
Travel Times	The time it takes to travel, either via car or transit, during the PM peak period for a set of typical trips in the region.
Person Volumes	The number of people traveling on a facility during a day or during a two–hour peak period.
Vehicle Miles of Travel	The number of miles all vehicles travel either for an entire day or during the PM peak period.
Mode Share	The number of people traveling by transit, carpool, or alone in their cars, averaged for an entire day or for the PM peak period.
Transit Ridership Potential	The potential for high-capacity transit usage within a designated corridor.

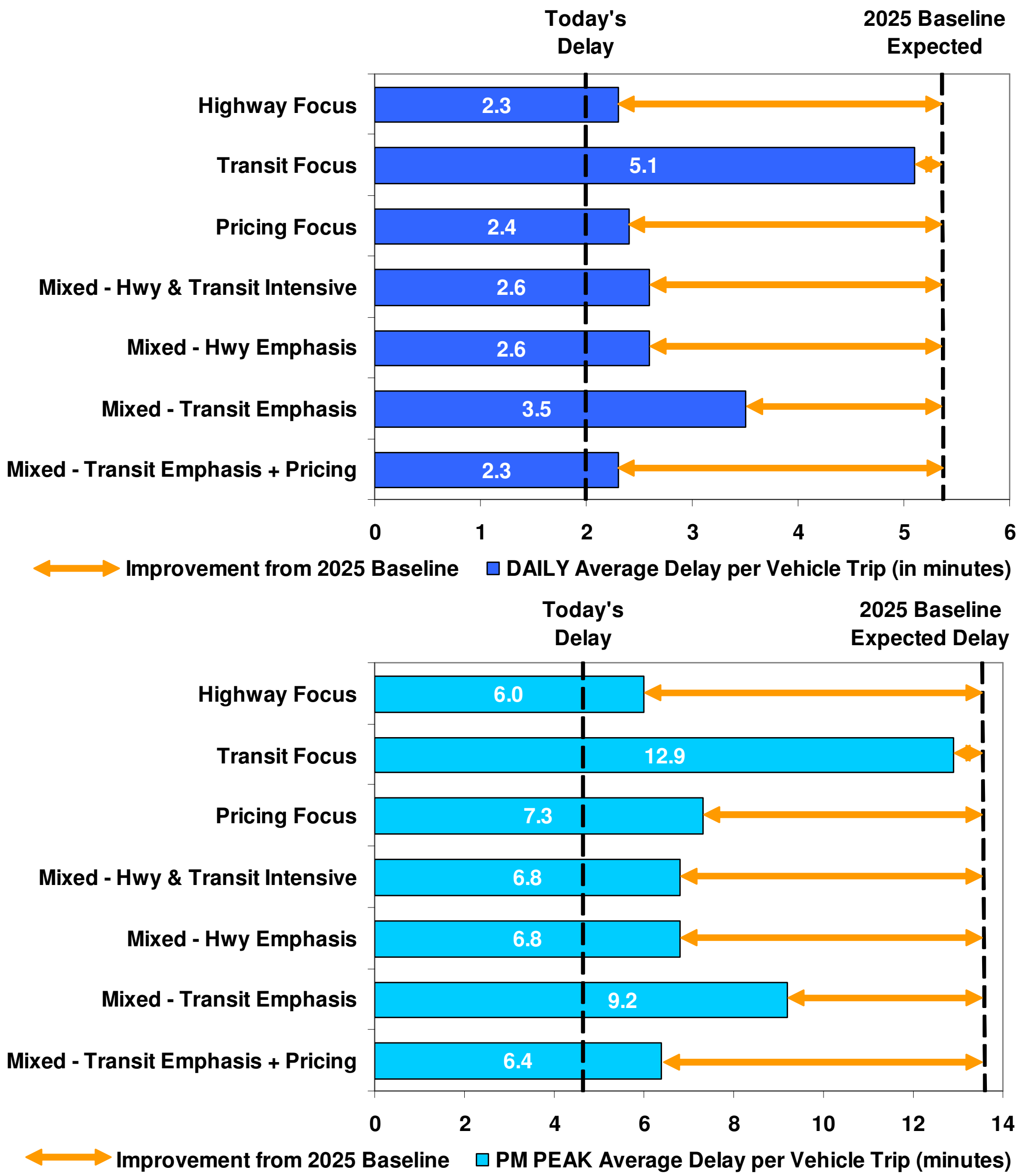
Vehicle Hours of Delay (VHD) and Delay per Vehicle Trip

Vehicle hours of delay measures the delay experienced by vehicles. There are two metrics used: 1) average delay per vehicle, which provides the average time delay for each vehicle trip generated in the region during the day and during the PM peak period, and 2) total vehicle hours of delay, which measures the daily and PM peak period delay experienced by all vehicles. Delay is defined as the difference between highway speed when traffic is operating at free flow conditions (typically near or at the speed limit) and the speed resulting from the traffic conditions in the scenario being modeled.

Average Delay per Vehicle Trip

A comparison of average daily and PM peak period delay per vehicle trip for all scenarios is shown in Figure 2-28. The average daily vehicle delay per trip, currently at two minutes, would increase by nearly 300% to over five minutes of delay per vehicle in 2025. The Pricing and Highway Focus Scenarios would reduce the average daily delay to a level slightly higher than existing conditions, and the delay per vehicle trip in the Transit Focus Scenario would remain similar to the 2025 Baseline. Most of the mixed scenarios would have delays that are at least 50% lower than the 2025 Baseline. The Transit Emphasis Mixed Scenario would reduce daily delay per vehicle by 35% compared to the 2025 Baseline. During the PM peak period the average delay per vehicle is now slightly more than four minutes, and in 2025 the delay would increase to 14 minutes. The scenarios would reduce peak period delays in similar proportions to those reported for daily conditions.

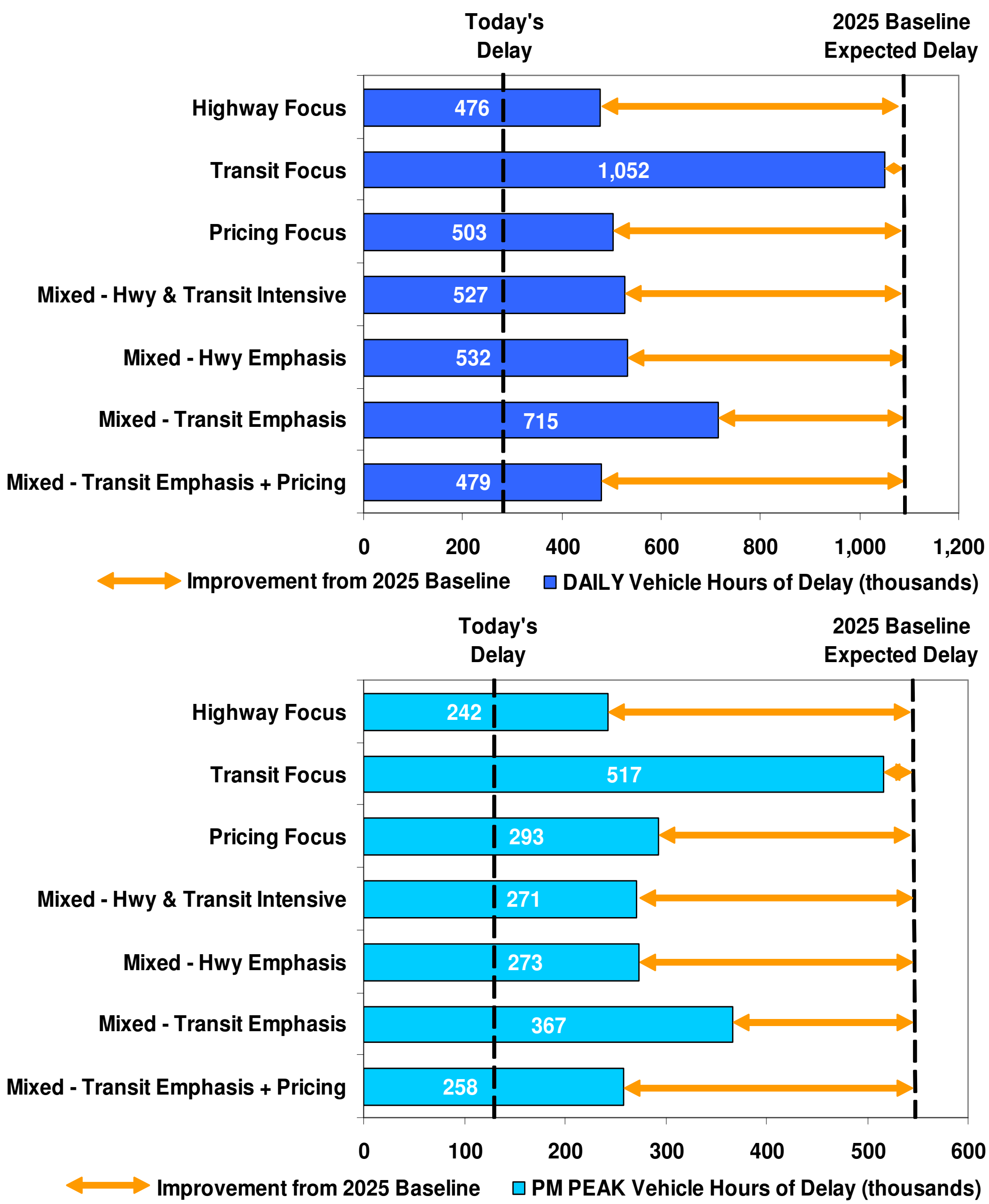
Figure 2-28: Average Delay per Vehicle Trip



Total Vehicle Hours of Delay

A comparison of total daily and PM peak period vehicle delay for all scenarios is shown in Figure 2-29. In the 2025 Baseline Scenario, the daily total vehicle delay would increase by nearly 300% as compared to existing conditions. Five of the seven scenarios would reduce daily vehicle delay to levels that are substantially lower than 2025 Baseline, but are 70 to 80% higher than existing delay. The Transit Emphasis with Pricing Mixed Scenario would achieve delay reductions comparable to those experienced in the Highway Focus Scenario. The Transit Focus Scenario would achieve minimal reductions in daily vehicle delay. During the PM peak period, the delay for all scenarios would reflect the same trends as shown for daily.

Figure 2-29: Total Vehicle Hours of Delay

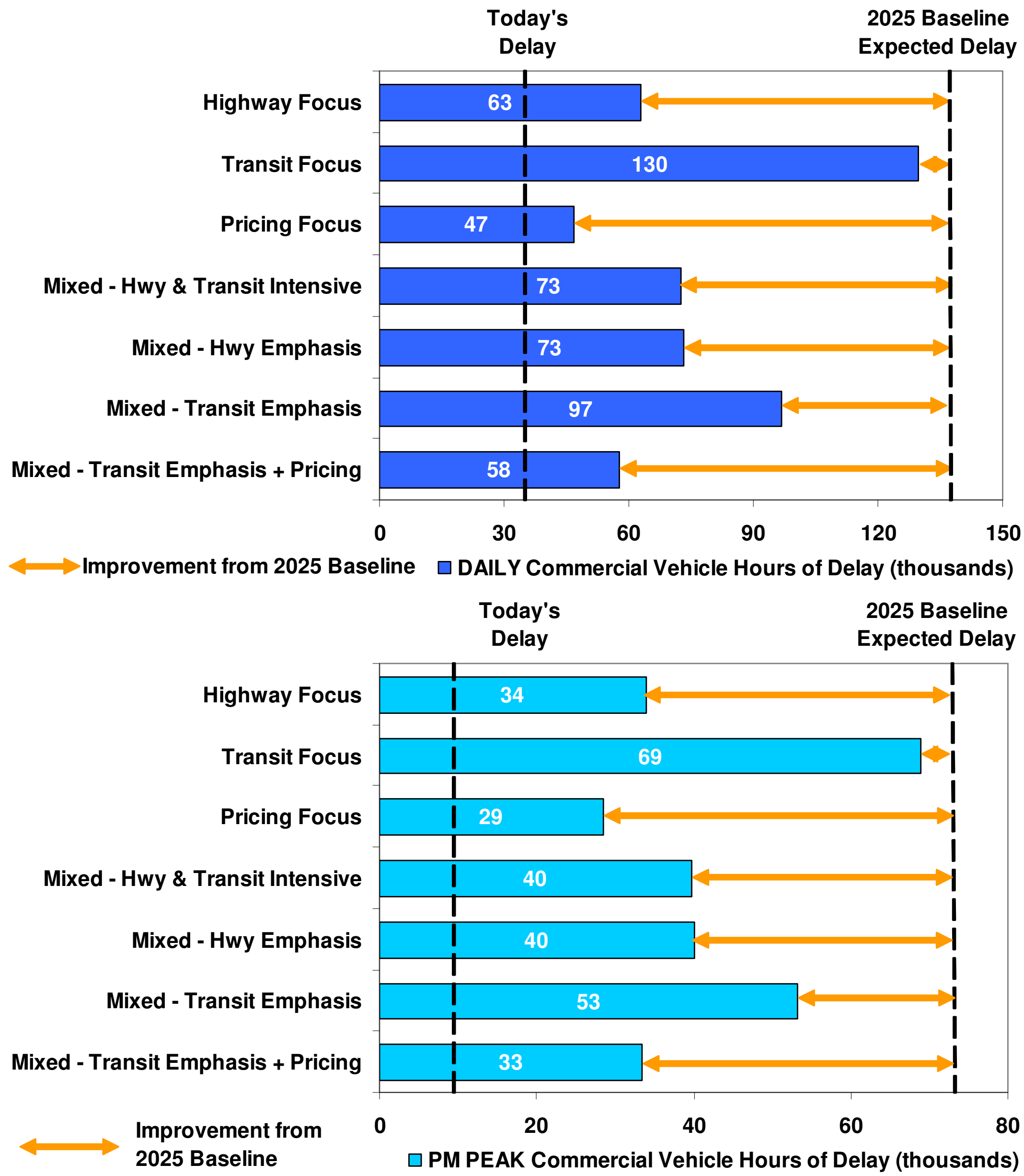


Relative to the 2025 Baseline Scenario, the Pricing Focus Scenario would result in delay reductions comparable to several of the other scenarios; unlike the other scenarios, however, it would achieve this by reducing vehicle use as reflected in shorter trip distances and shifting to use other travel options. In considering the economic benefits of reducing congestion through the introduction of value pricing (discussed later in this report), it is necessary to also consider the disbenefits resulting from users making compromises in their travel behavior to minimize transportation costs.

Commercial Vehicle Hours of Delay (daily)

Figure 2-30 summarizes the commercial vehicle hours of delay for each scenario. Commercial vehicle delay closely tracks the trends for GP traffic shown in Figure 2-29. In the 2025 Baseline Scenario, total daily commercial vehicle hours of delay would increase by nearly 300% compared to existing conditions. The scenarios that emphasize highway investments are those that produce the greatest reductions in commercial vehicle delays. During the PM peak period, the hours of delay for all scenarios would reflect the same trends as shown for daily.

Figure 2-30: Commercial Vehicle Hours of Delay



Vehicle Delay per Mile

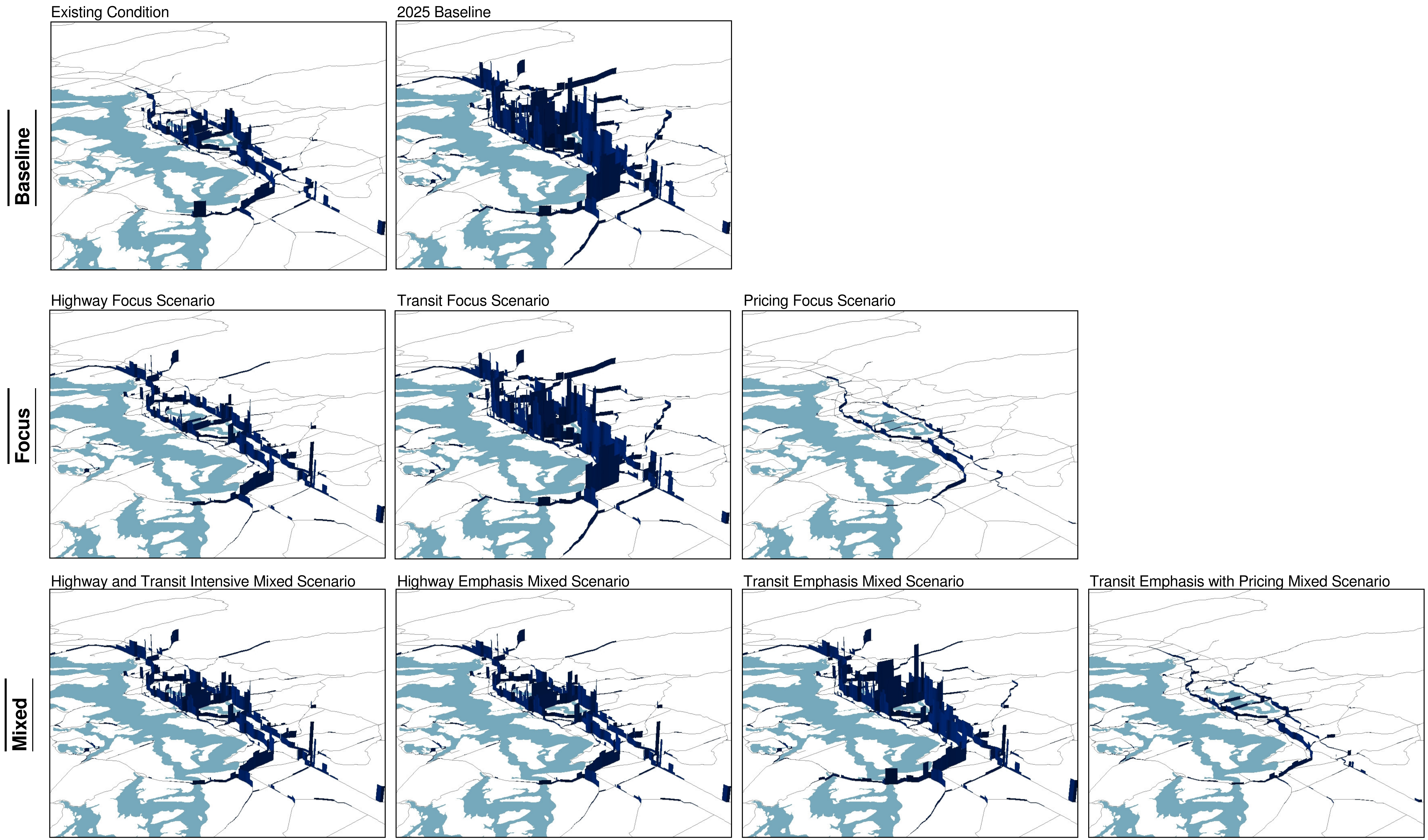
Vehicle delay per mile provides a metric of congestion intensity that can be examined on a corridor or segment basis. Figure 2-31 shows total daily delay per mile on the state highway system in the central Puget Sound region. As seen in the first row, delay per mile is expected to increase substantially on most highways from now until 2025 in the baseline condition. The greatest delay will be experienced in the central portion of the region along the major freeways.

The second row shows the results of the three scenarios focused on single modes. The Highway Focus Scenario would reduce delay per mile to a level that is similar to existing conditions, with improvements shown along key roadway segments such as I-405, I-5 through Seattle, and across the Lake Washington bridges. The Transit Focus Scenario shows few improvements in delay compared with the 2025 baseline condition. The Pricing Focus Scenario reduces delay on virtually all of the state highway segments, partly due to the diversion of some vehicle trips to non-priced parallel arterial routes.

The third row shows the four mixed scenario results. The Highway and Transit Intensive Mixed Scenario and the Highway Emphasis Mixed Scenario each include the same roadway improvements, with resulting delay per mile results that are very similar. These two scenarios perform about the same as the Highway Focus Scenario with one-third fewer lane miles added. The exception is in the central part of the region where these scenarios are less effective in reducing delay on I-5, I-405 and across Lake Washington.

The Transit Emphasis Mixed Scenario also shows improvements compared with the 2025 baseline, although high levels of delay persist along several major highways. When value pricing is added to the Transit Emphasis Mixed Scenario, however, delay per mile on these highways decreases to levels that are better than existing conditions. This improvement is due, in part, to the diversion of some vehicle trips to non-priced parallel arterial routes.

Figure 2-31: Delay per Mile on State Highways and Interstate Freeways (Delay on local roadways not shown)



Congested Hours per Day

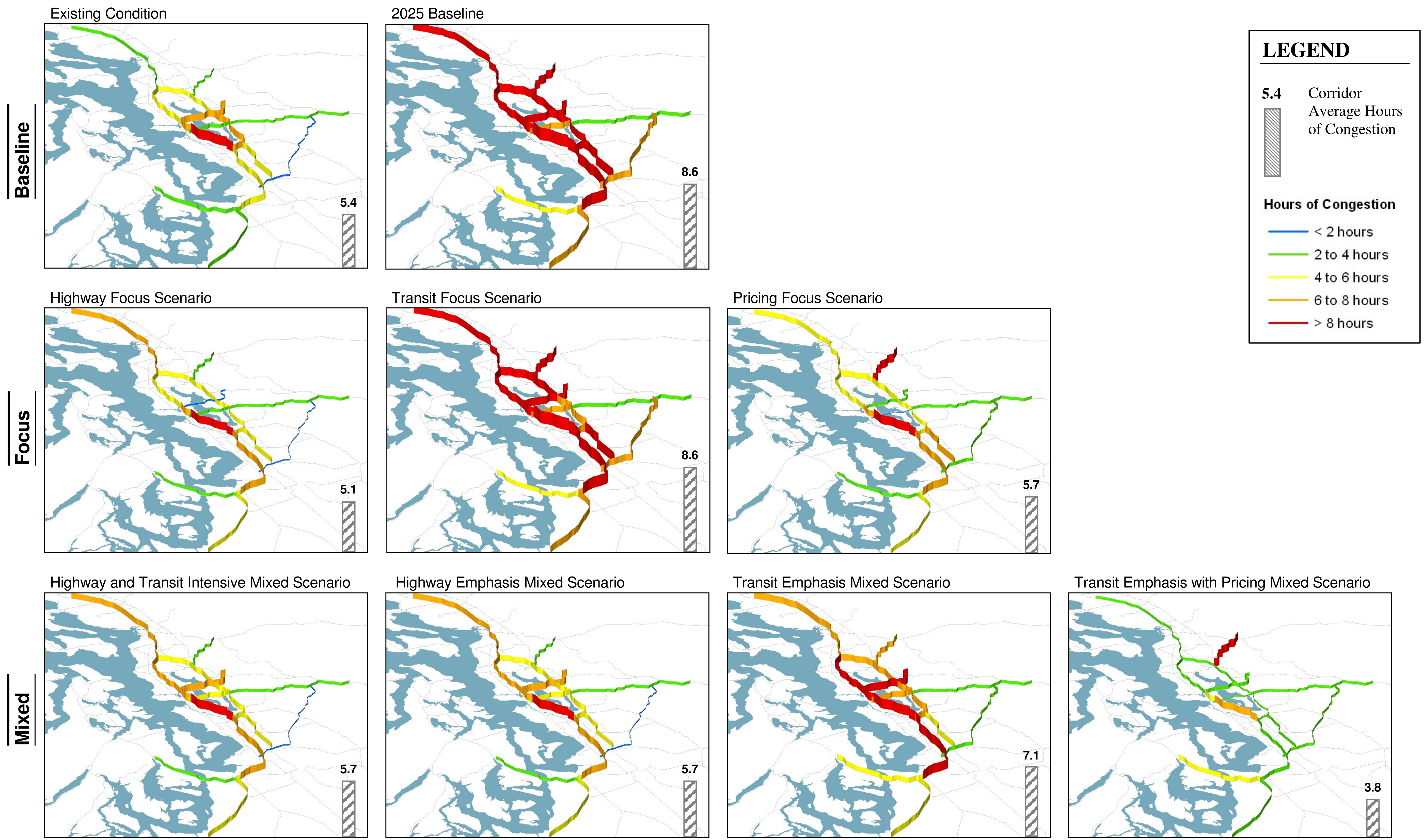
Another way to measure congestion is to look at the number of hours per day during which a roadway is congested. Congestion was measured along the major highway facilities within each of the 13 study corridors. The set of maps in Figure 2-32 illustrates the duration of traffic congestion that exists today and the congestion levels that are forecast for each scenario.

The first row compares existing congestion with 2025 Baseline. Currently, most corridors in the central Puget Sound region show extended periods of congestion, on average approximately five hours per day. The most congested facilities are I-5, I-405, SR 520 and SR 167. By 2025, traffic flow in all corridors is forecast to deteriorate substantially, with freeway corridors experiencing about nine hours of congestion during the day. Much of the growth in congestion is evident in the northern portion of the region, along I-5 in North Seattle and Snohomish County, I-405 north of Bellevue, and SR 522 to Monroe. Conditions are also forecast to deteriorate along I-5 and SR 167 in South King/North Pierce Counties and along SR 18.

The second row *shows the three focus scenarios. The Highway and Pricing Focus Scenarios improve congestion duration substantially, to levels similar to existing conditions.*
Corridors that would benefit most from the Highway Focus Scenario investments include I-5 from downtown Seattle south to Tacoma, I-405 south from Bellevue to Tukwila, SR 520 across Lake Washington, and SR 167 in South King/North Pierce Counties. Corridors that would benefit most from the Pricing Focus Scenario include the Lake Washington bridges (I-90, SR 520), portions of I-5 through Seattle, and I-405. Some corridors where there are few available alternative routes (e.g. SR 522 and I-90 east) showed minimal improvements in congestion. The Transit Focus Scenario shows minimal changes in congestion duration compared with the 2025 Baseline. Minor reductions (i.e., less than 0.5 hours) in congestion would occur along the I-5 central corridor, on the I-90 and SR 520 bridge crossings, and on the segment of I-90 to the east of I-405.

The third row shows the results of the mixed scenarios. The Highway and Transit Intensive Mixed Scenario and the Highway Emphasis Mixed Scenario would substantially improve corridor congestion levels, although levels would still be slightly higher than existing conditions. Corridors that would benefit the most include I-5 from downtown Seattle south to Tacoma, SR 18, SR 522, and SR 167. The Transit Emphasis Mixed Scenario substituted highway capacity with expanded transit investment. Although this scenario would reduce congestion compared to 2025 Baseline, congestion levels would be substantially higher than existing conditions. When value pricing is added to this scenario, the average corridor congestion improves to less than 4 hours, which is the lowest of the scenarios tested. Value pricing seems to complement the combined transit and highway investment reflected in this scenario. The locations that would benefit most from value pricing are the main north-south freeways (I-5, I-405, SR 167) and the Lake Washington bridges (I-90, SR 520). The SR 16 corridor showed minimal change in congestion, since it was already assumed to be priced (as part of the Tacoma Narrows Bridge project). Congestion would increase on SR 522, since it was not priced as part of this scenario.

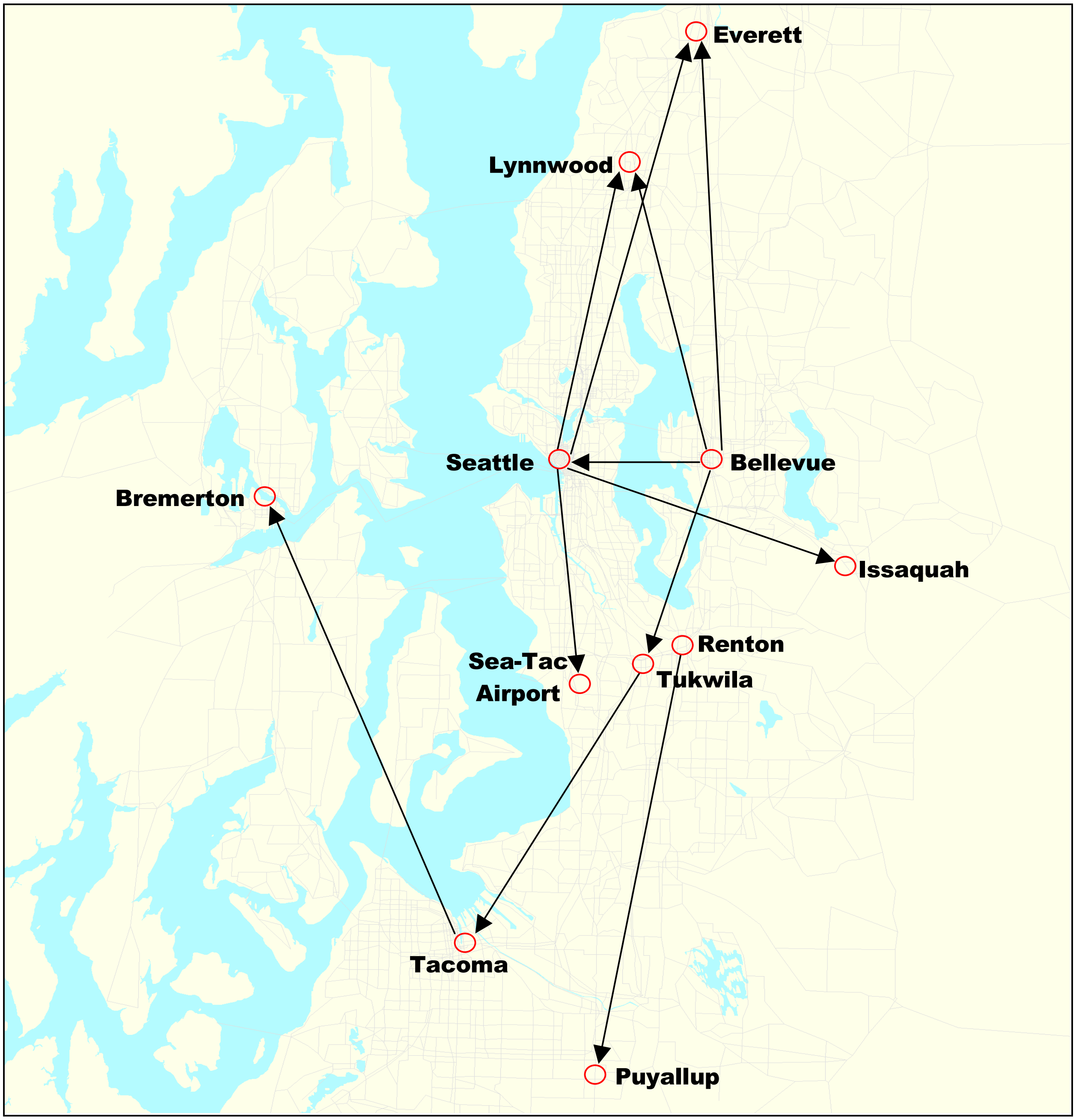
Figure 2-32: Congested Hours per Day on Interstate and State Highways



Origin-Destination (O-D) Travel Times

Travel time – the time it takes to go from "here to there" – is important to all travelers. Travel time was estimated for GP traffic and transit trips in the peak direction of travel during the afternoon commute. Figure 2-33 depicts eleven origins and destinations for travelers in the central Puget Sound region. Major activity centers were chosen as the origins (beginning of a trip) and the destinations (end of a trip) for determining point-to-point travel times for the PM peak period (two hours). Travel time activity centers include Seattle, Tacoma, Bellevue, Tukwila, and Renton, and destinations include Everett, Lynnwood, Seattle, Issaquah, Tukwila, Puyallup, Tacoma, Sea-Tac Airport and Bremerton.

Figure 2-33: Selected Commuter Routes in the Central Puget Sound Region



General Purpose (GP) Traffic

Table 2-7 shows the point-to-point travel times for GP traffic. Included in the table is a comparison of existing travel times from the travel demand model and average commuter travel times, as reported on the WSDOT Web site. In most cases, the WSDOT commuter routes are slightly shorter than the point-to-point routes used elsewhere in the table. This explains why the travel time values are generally lower when compared with the modeled results.

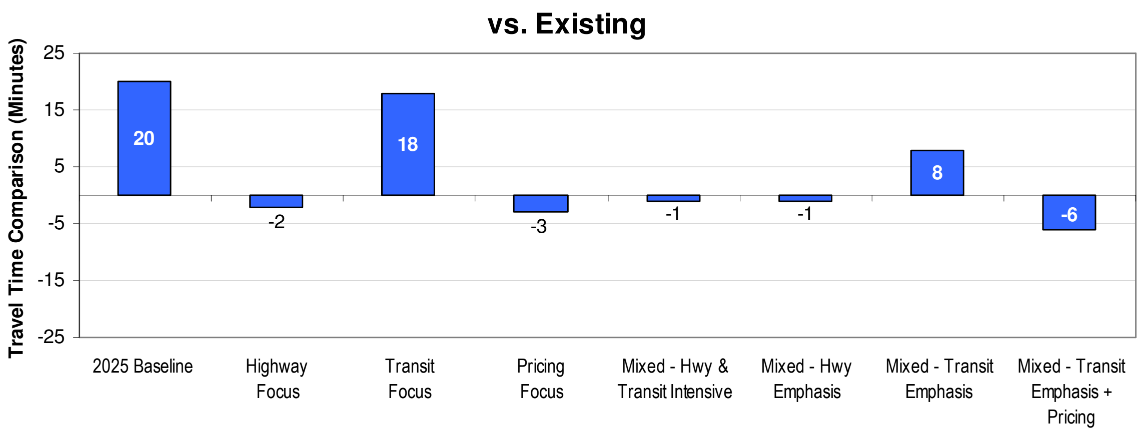
Table 2-7: Point-to-Point Travel Time for General-Purpose Traffic (Two-Hour PM Peak Period)

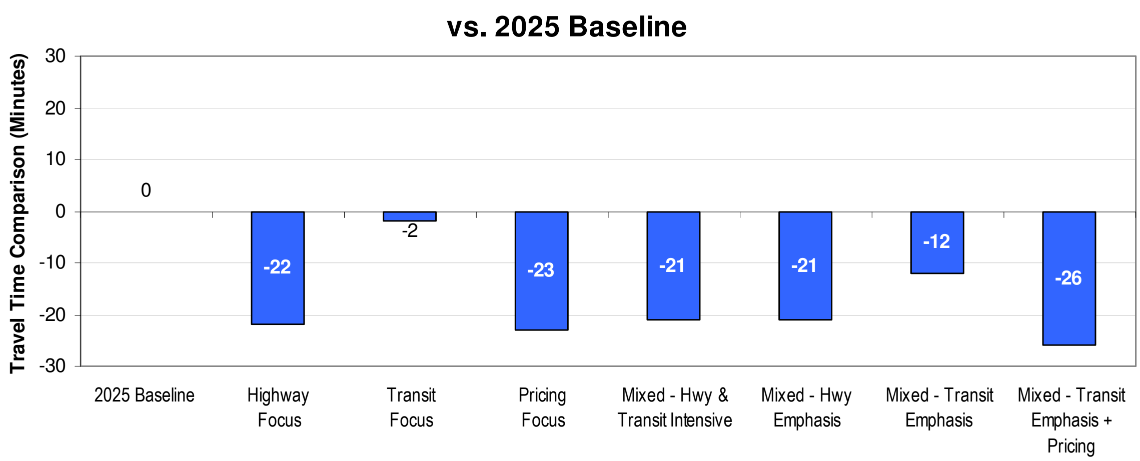
Commuter Routes	WSDOT Web site (2002)[6]	Existing	2025 Baseline	Highway Focus	Pricing Focus	Transit Focus	Highway and Transit Intensive Mixed Scenario	Highway Emphasis Mixed Scenario	Transit Emphasis Mixed Scenario	Transit Emphasis with Pricing Mixed Scenario
Bellevue to Everett	36	39	67	40	41	66	42	42	48	31
Seattle to Everett	41	43	71	43	42	69	44	44	53	33
Seattle to Sea-Tac Airport	20	25	30	21	22	30	22	22	24	18
Bellevue to Tukwila	26	32	51	24	24	48	27	27	32	20
Seattle to Issaquah	24	30	40	30	25	38	34	34	40	26
Bellevue to Seattle	20	20	35	21	19	33	25	25	31	19
Renton to Puyallup	n/a	50	82	49	49	79	49	49	57	38
Tukwila to Tacoma	n/a	48	74	46	44	72	46	46	52	32
Tacoma to Bremerton[7]	n/a	53	67	47	49	65	48	48	75	67
Seattle to Lynnwood	n/a	30	43	29	27	41	30	30	35	22
Bellevue to Lynnwood	n/a	31	47	32	31	46	34	34	37	25
Overall Average for 11 Routes	*n/a*	*40*	*60*	*38*	*37*	*58*	*39*	*39*	*48*	*34*

[6] Travel times for commuter routes reported on the WSDOT Web site are different than reported elsewhere in this table due to slight variations in start and end points. N/A = data not reported by WSDOT for this commuter route.
[7] The travel times worsen from Tacoma to Bremerton because the Transit Emphasis Scenario includes widening of I-5 in Tacoma but no widening of SR 16. This attracts additional traffic to SR 16 creating a more congested trip. The additional of pricing on I-5 reduces the additional traffic demand on SR 16 and results in improved travel times for this commuter route.

Figure 2-34 shows the average highway travel time savings for all 11 point-to-point routes in relation to the Existing and 2025 Baseline Scenarios. With 2025 Baseline, the average travel times for evening peak hour trips along these selected routes are expected to increase by almost 50% by 2025. For example, travel from downtown Seattle to Everett during the PM peak period currently takes approximately 43 minutes, and by 2025 it is expected to take 71 minutes. Going from Bellevue to Tukwila, a ten-mile trip is forecasted to take 51 minutes in 2025 compared with 32 minutes currently.

Figure 2-34: Average PM Peak Period GP Travel Time Comparisons for Selected Routes





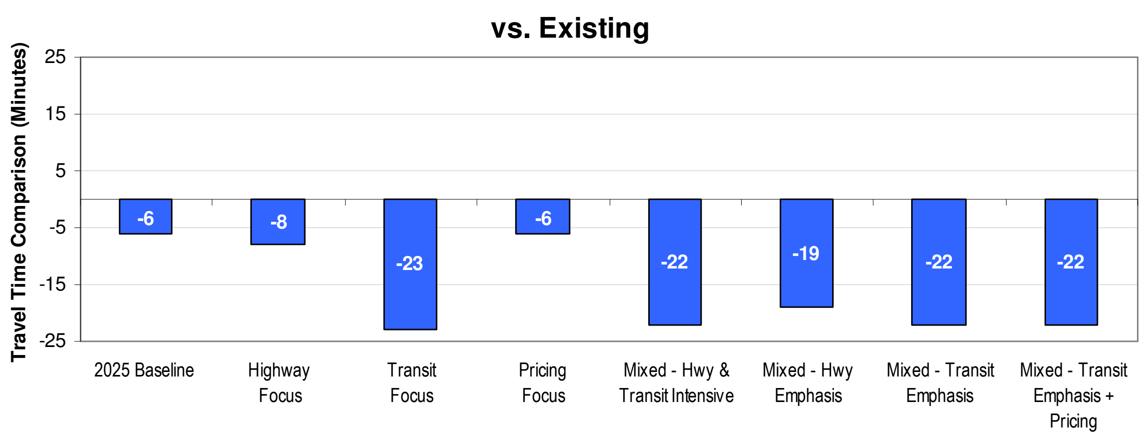
For GP traffic traveling on these routes, the Highway Focus Scenario would save, on average, 22 minutes of travel time compared to the 2025 Baseline Scenario, and the Pricing Focus Scenario would have similar savings. When a high level of highway investment (i.e., Highway Emphasis or Highway and Transit Intensive Mixed Scenarios) is joined with either a high or low transit investment, the travel time savings would be nearly the same, approximately 21 minutes. These travel times are slightly lower than existing times. The Transit Emphasis Mixed Scenario would achieve approximately half of these time savings. However, when value pricing is added to the Transit Emphasis Mixed Scenario, the travel time savings would be 26 minutes compared with the 2025 Baseline Scenario, and would result in a savings of 6 minutes compared to current travel times. Overall, the travel time benefits along these specific corridors are greater than the system-wide delay savings. This implies that investments targeted along major travel routes could provide substantial benefits to commuters and other travelers during peak periods.

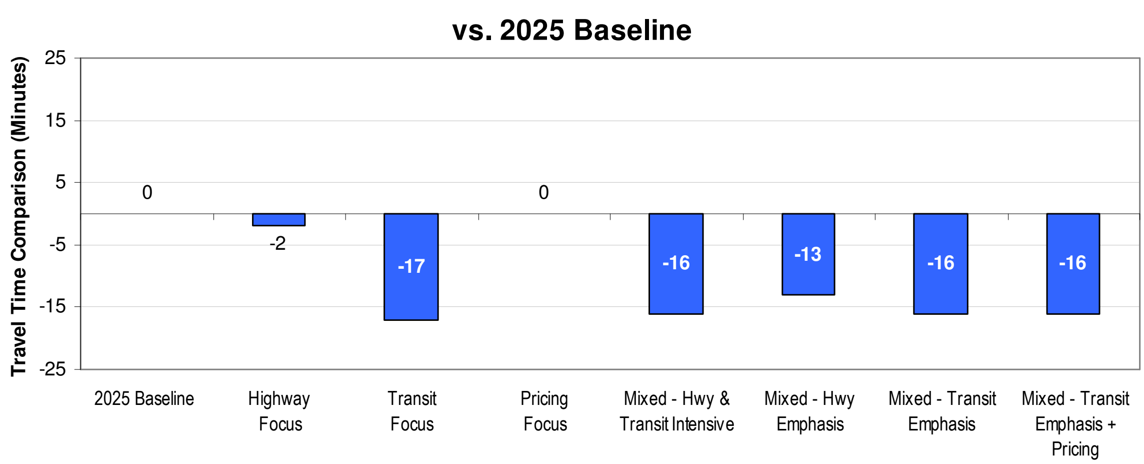
Transit

Transit travel times include in-vehicle time, wait time, and transfer times. In contrast to GP traffic conditions, transit travel times are expected to remain relatively constant between now and 2025. Some transit travel times are actually expected to improve by 2025 due to already committed improvements to the transit system.

Figure 2-35 shows the average transit travel time savings for the point-to-point routes in relation to the Existing and 2025 Baseline Scenarios. The transit travel time savings (compared to 2025 Baseline) would be approximately 16 minutes for all scenarios that include a high level of transit investment. These include the Transit Focus Scenario and most of the mixed scenarios. In these scenarios, transit times would increase slightly for certain trips due to assumptions regarding high-capacity transit lines and the transfer times between modes.

Figure 2-35: Average PM Peak Period Transit Travel Time Comparisons for Selected Routes





The Highway and Pricing Focus Scenarios would save a minimal amount of transit travel time compared to the 2025 Baseline Scenario; they do not assume any additional investments in transit beyond those included in the 2025 Baseline Scenario. In contrast, the Highway Emphasis Mixed Scenario would save 13 minutes of transit travel time, because it includes several high-capacity transit lines and expanded express bus services together with the highway improvements.

Person Volumes Compared to Unconstrained Highway Demand

Person volumes were compared among scenarios at several locations throughout the region. The purpose was to assess how well each scenario would serve the potential travel demands in 2025. To accomplish this comparison, person volumes were recorded at seven screenlines within the region, as shown in Figure 2-36. Screenlines are imaginary lines drawn across several parallel roadways and other transportation facilities, and are used as a reference point for measuring or reporting travel volumes.

One of the starting points was an analysis of "capacity-unconstrained demand". The purpose of this analysis was to give an indication as to what travel route people would choose in 2025 if there were no limits on available capacity or any traffic congestion. While constraints on travel obviously exist throughout the central Puget Sound region, the unconstrained model results were used as one reference point for comparing the person demand created by the scenarios.

Figure 2-36: Central Puget Sound Region Screenlines

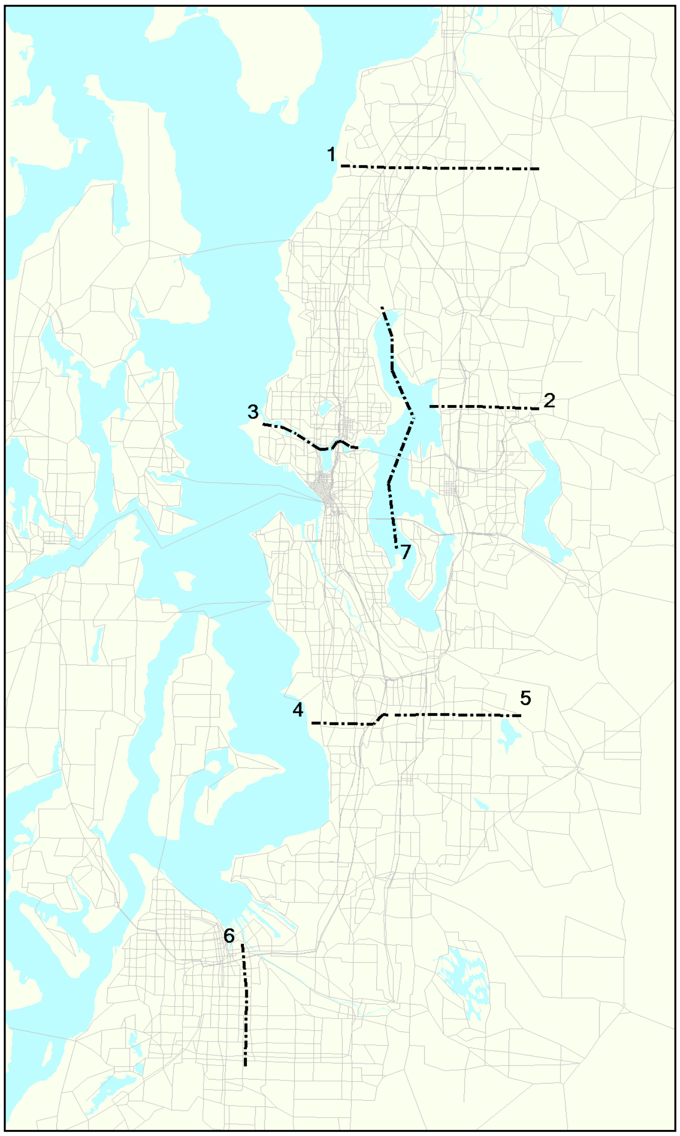
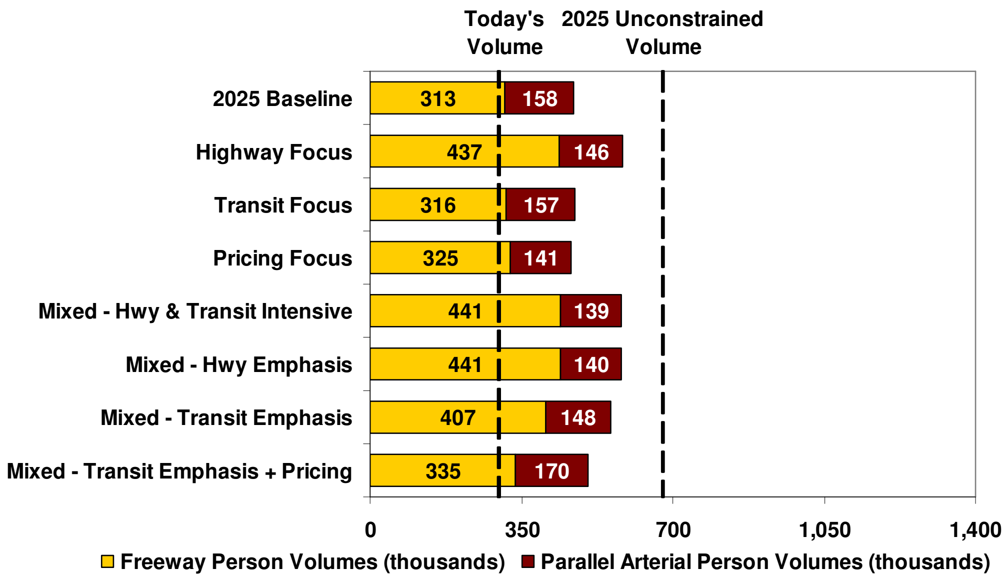


Figure 2-37 through Figure 2-43 compare the person volumes at seven screenlines. At each screenline location, the 2025 unconstrained demand would substantially exceed existing and 2025 Baseline person demand. In the unconstrained demand analysis, the model showed a tendency for people to change routes from lower speed arterials to higher speed freeways. This shift from arterials to freeways shows an over-utilization of freeways (assuming current freeway capacity) and under-utilization of arterials (with current arterial capacity).

The Highway Focus Scenario would accommodate approximately 80% of the unconstrained demand at the screenlines. Conversely, the Pricing Focus Scenario would only capture around two-thirds of the unconstrained demand. The dynamics of value pricing complicate this comparison, due to a combination of mode shifts (discussed later in this report) and changes in trip lengths throughout the region. The Transit Focus Scenario would accommodate approximately 70% of the unconstrained demand. The mixed scenarios show results that fall within these ranges.

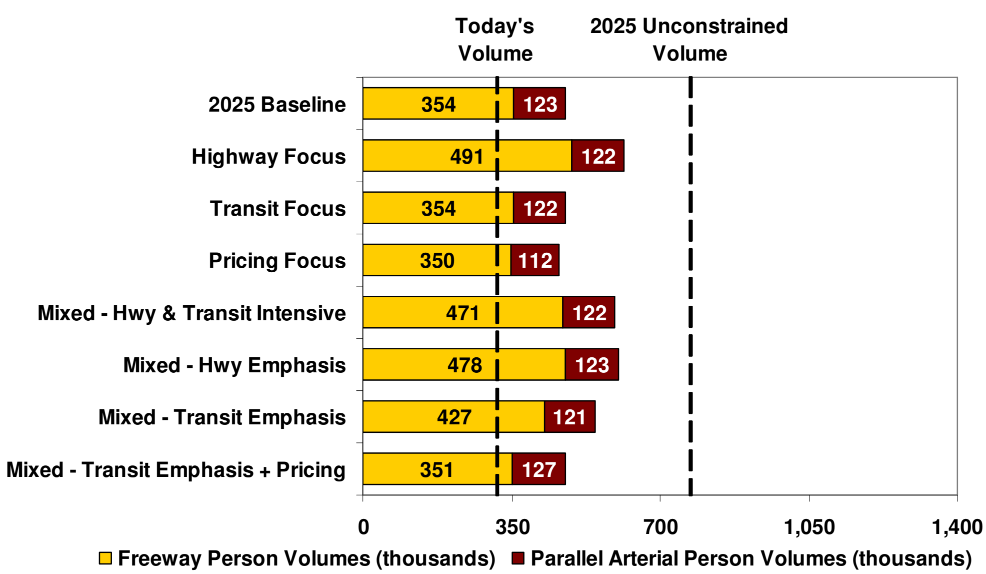
North of 148th St SW (Between SR 99 and SR 527 in Snohomish County) – This screenline was used to analyze north-south travel in Snohomish County, including I-5. The Highway Focus Scenario and mixed scenarios with a high level of highway investment would serve the highest person demand, up to 85% of the capacity-unconstrained demand.

Figure 2-37: Daily Person Volumes – North of 148th Street SW between SR 99 and SR 527 in Snohomish County



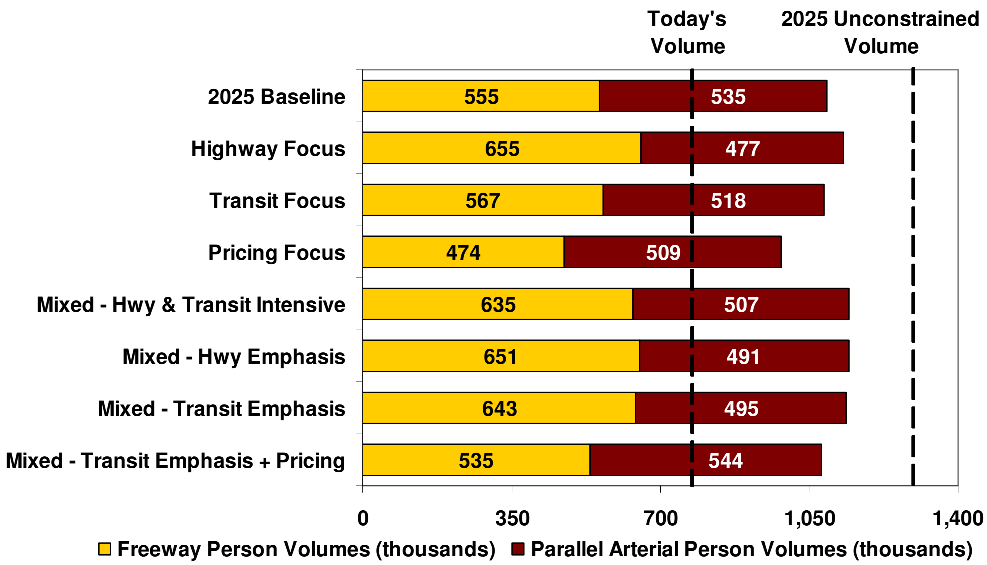
North of NE 85th St (Between Lake Washington and Avondale Road in Kirkland/Redmond) – This screenline was used to analyze north-south travel on the Eastside along the I-405 corridor. The Highway Focus Scenario and mixed scenarios with a high level of highway investment would serve the highest person demand, up to 80% of the capacity-unconstrained demand.

Figure 2-38: Daily Person Volumes – North of NE 85th Street between Lake Washington and Avondale Road in Kirkland/Redmond



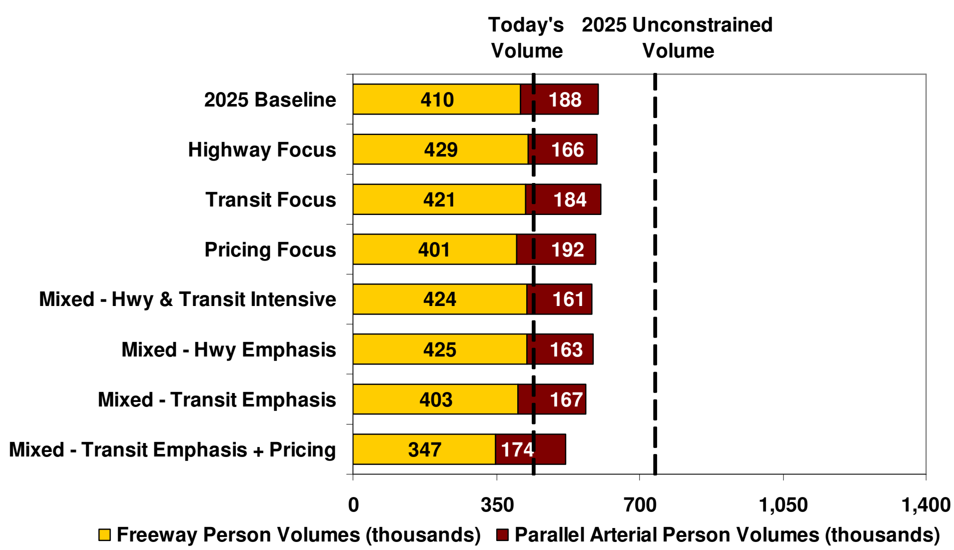
Ship Canal (Between the Ballard Bridge and Mountlake Boulevard in Seattle) – This screenline was used to analyze north-south travel across the Ship Canal in Seattle, including I-5. The Highway Emphasis Mixed Scenario and the Highway Focus Scenario would accommodate over 85% of the capacity-unconstrained demand. The Transit Emphasis Mixed Scenario and Transit Focus Scenario are close behind, with transit person volumes accounting for a substantial portion of the total person demand. The Pricing Focus Scenario would result in the lowest person volumes.

Figure 2-39: Daily Person Volumes – Ship Canal between Ballard Bridge and Mountlake Boulevard



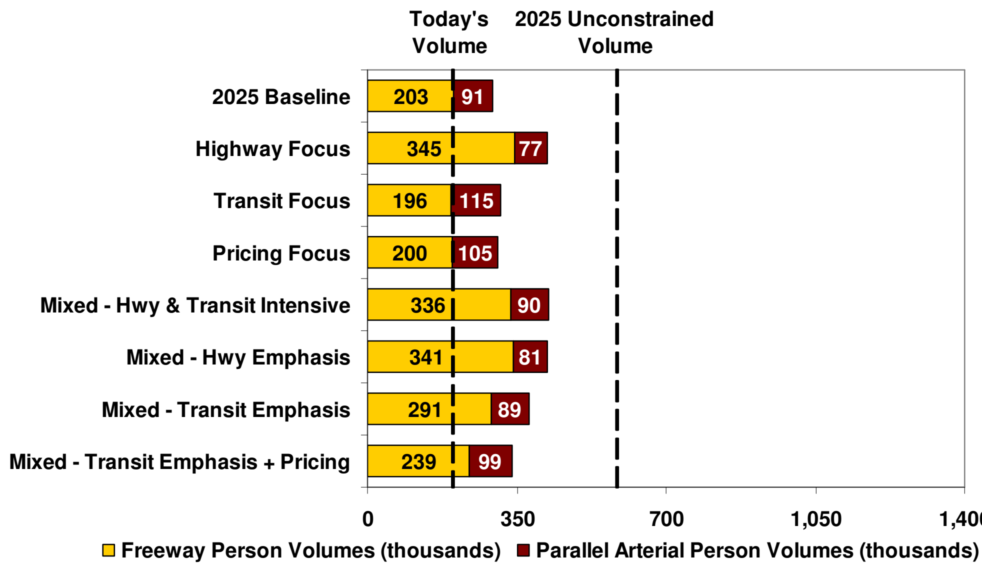
South of South 188th Street (Between SR 509 and I-5 in Sea-Tac) – This screenline was used to analyze north-south travel in South King County, including SR 509 and I-5. Each of the scenarios, including the 2025 Baseline Scenario, would serve similar person demand (up to 80% of unconstrained demand). The lack of variation among the scenarios can be attributed to high demand in the corridor with few alternative routes.

Figure 2-40: Daily Person Volumes – South of S. 188th Street between SR 509 and I-5 in Sea-Tac



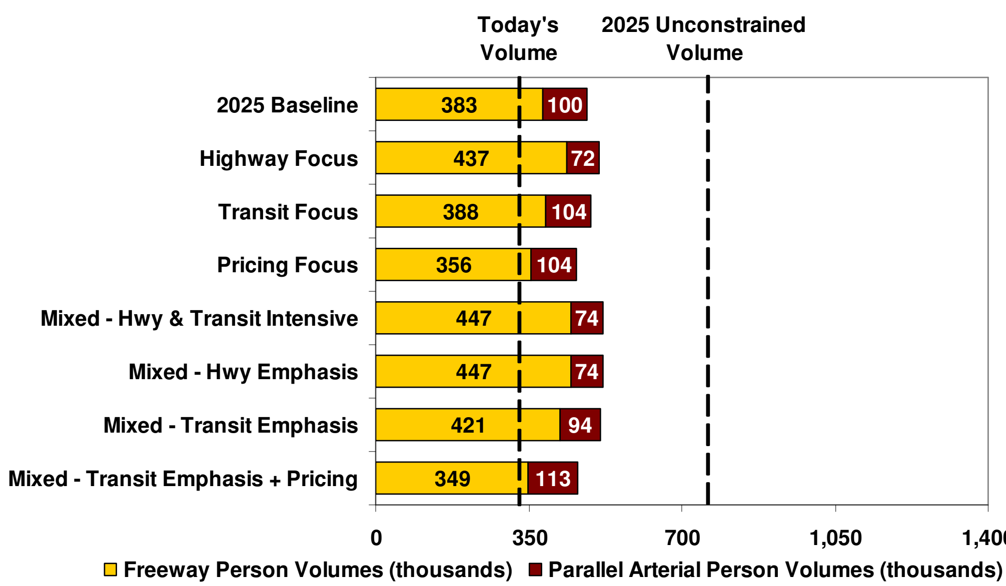
South of South 188th Street (Between SR 181 and SR 515 in Kent) – This screenline was used to analyze north-south travel in the Green River Valley of South King County, including SR 167. The Highway Focus Scenario and mixed scenarios with a high level of highway investment would serve the highest person demand, up to 75% of the capacity-unconstrained demand. The Transit and Pricing Focus scenarios would serve the lowest screenline demand.

Figure 2-41: Daily Person Volumes – South of S. 188th Street between SR 181 and SR 515 in Kent



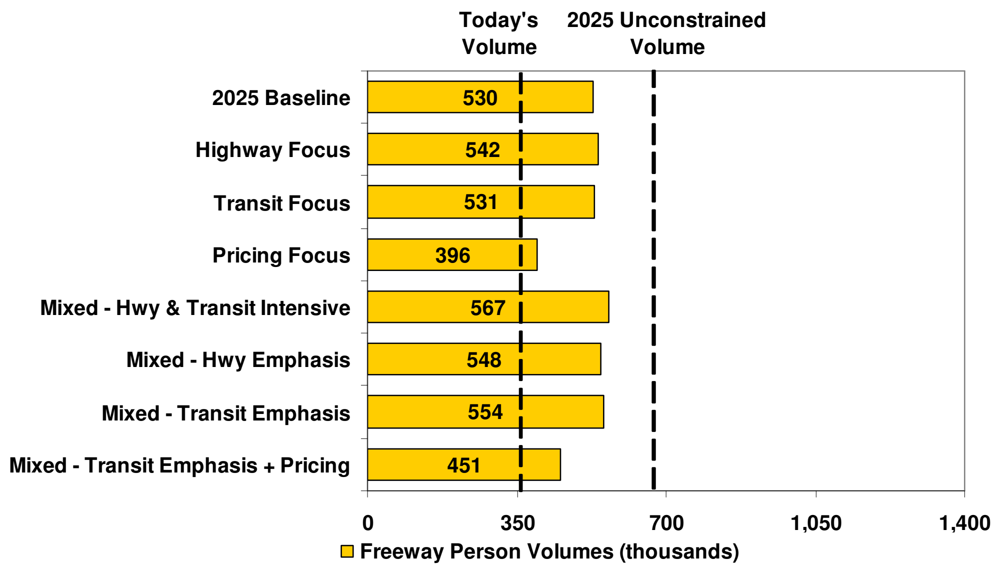
East of Downtown Tacoma (Between I-5 and SR 512 in Tacoma) – This screenline was used to analyze north-south travel through Tacoma in Pierce County. The screenline includes the I-5 and SR 512 freeways and arterial routes. Each of the scenarios, including the 2025 Baseline Scenario, would serve similar person demand (up to two-thirds of unconstrained demand). The Pricing Focus Scenario would result in slightly lower demand across the screenline.

Figure 2-42: Daily Person Volumes – East of Downtown Tacoma between I-5 and SR 512 in Tacoma



Lake Washington Bridges (SR 520, I-90) – This screenline was used to analyze east-west travel across Lake Washington between Seattle and the Eastside; it includes the I-90 and SR 520 Bridges. Each of the non-priced scenarios, including the 2025 Baseline Scenario, would serve nearly 80% of the unconstrained demand. The highway-oriented scenarios would all add capacity to the SR 520 Bridge, while I-90 capacity would remain unchanged; despite the added capacity, the person demand would remain relatively unchanged across the lake. Since highway capacity would be added to other facilities such as I-405 and I-5, regional travel patterns would shift, resulting in fewer trips crossing the lake. The Highway and Transit Intensive Mixed Scenario carries a comparable number of vehicle persons to the Highway Focus Scenario, but also carries more transit persons across the Lake. The Pricing Focus Scenario would result in slightly lower demand across this screenline as a result of shorter trip lengths and fewer trips crossing the lake.

Figure 2-43: Daily Person Volumes – Lake Washington Bridges SR 520 and I-90

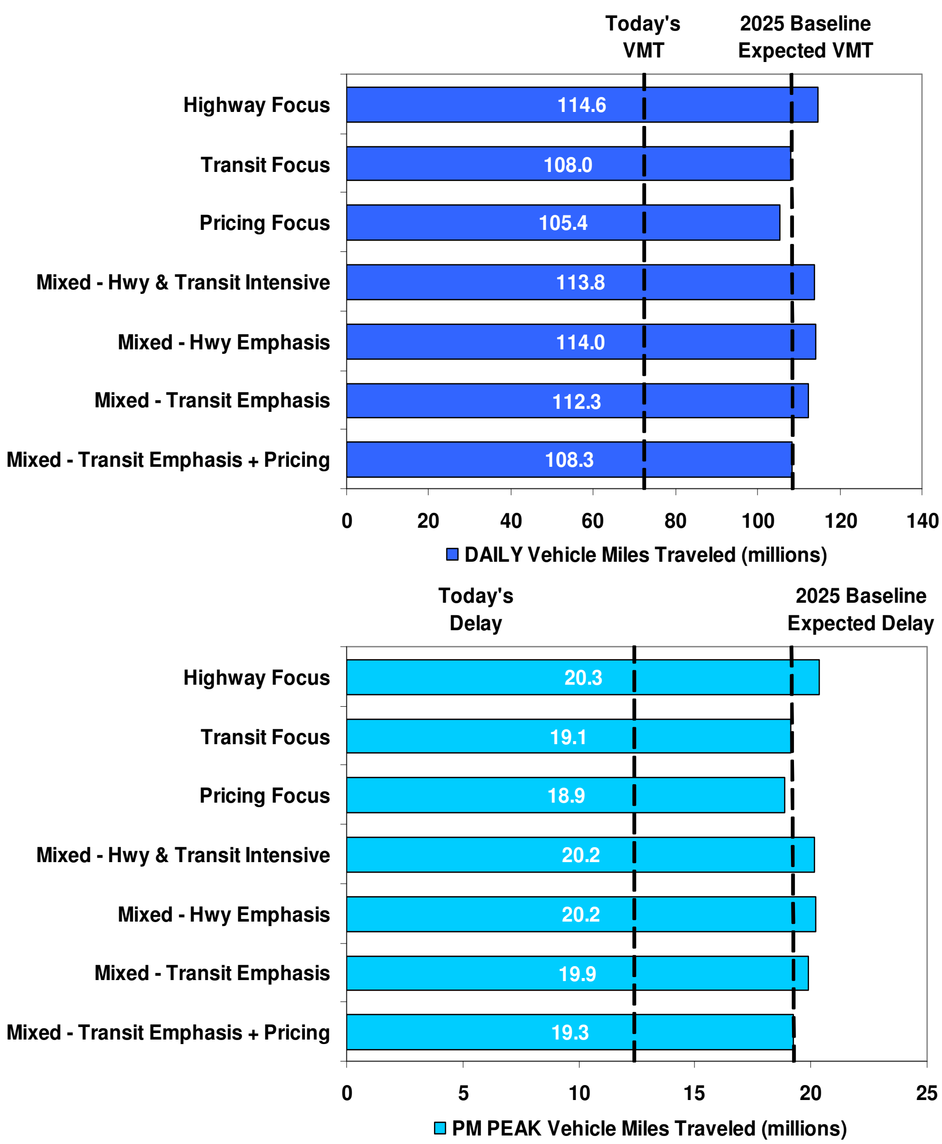


Vehicle Miles Traveled

Vehicle miles of travel (VMT) is a metric of total vehicle trips per day multiplied by the length of the trip (in miles). VMT was summarized at the regional level and portrays overall changes in travel activity that may occur in response to a scenario.

Figure 2-44 summarizes the changes in regional VMT during the PM peak period and daily conditions. Within the region, daily VMT is forecast to increase nearly 60% by 2025 for the 2025 Baseline Scenario. The growth in PM peak period VMT is expected to occur at a similar pace.

Figure 2-44: Vehicle Miles Traveled



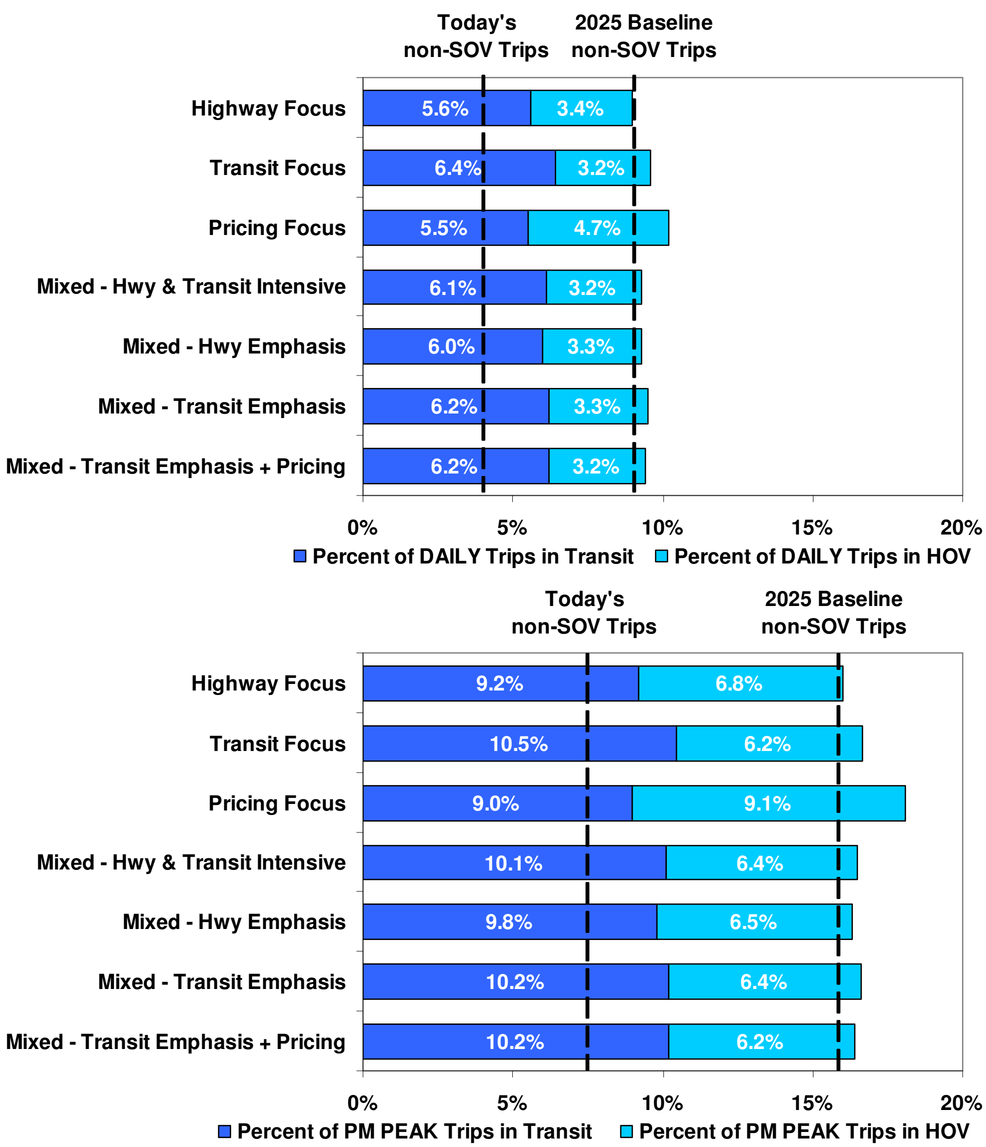
The daily and peak period VMT are similar among all scenarios. This is not surprising, given the assumption of the same regional growth forecasts. Those scenarios with slightly higher VMT have higher levels of highway investments. The Highway Focus Scenario would result in a 5% increase in VMT as a result of increasing trip lengths. Conversely, the Pricing Focus Scenario would result in a small decrease in VMT due to a shift to shorter trips. These changing trip patterns and trip lengths illustrate many of the effects of induced travel within the region; induced travel is addressed in the Environmental Review discussion.

Mode Share

This metric looked at the percentage of daily and PM peak period trips made by transit and HOV modes. The mode shares represent an average of all trips taken in the region during these time periods.

Figure 2-45 shows a comparison of transit and HOV mode shares across all scenarios. In the 2025 Baseline Scenario, the daily transit mode share is forecast to increase from 3% in existing conditions to just under 6%. The PM peak period transit share in 2025 would exceed 9%. HOV (3+) mode share during the same PM peak period would be around 7%. This metric showed very little difference among the scenarios

Figure 2-45: Transit and HOV Mode Share



Transit and HOV mode shares would remain steady among the scenarios and appear to be relatively unaffected by various investments in highway or transit modes. This may be, in large part, due to the assumed completion of the regional core HOV system in each scenario, thereby providing consistent transit/HOV travel times regardless of the scenario.

The Pricing Focus Scenario showed the highest transit/HOV mode share of around 18% during the PM peak period. While transit shares remained unchanged, the number of carpool trips (HOV 3+) was forecasted to increase by nearly 50% compared to the other scenarios. As a result, the Pricing Focus Scenario would have 178,000 fewer daily non-carpool trips – a reduction of 1.2% compared with the 2025 Baseline Scenario. Along the major regional corridors, the Pricing Focus Scenario also reduces total daily person volumes by around 8%, while daily vehicle trips would decrease by 13%.

The Effects of Pricing on Transit Usage

Why does the model predict that the transit mode share will not increase under widespread pricing? The two CRA scenarios that included pricing in the Central Puget Sound region made the assumption that HOVs (3+) would travel toll-free wherever tolls were applied. This created a compelling incentive for travelers to form carpools. In addition, the PSRC travel demand model, while good at capturing the trip redistribution (shortening) effects of pricing, is limited in its ability to simulate other expected travel responses to pricing. Although the development of special model procedures for handling time shifting and trip elimination were beyond the scope of this study, such procedures would likely improve the model's ability to estimate transit mode share changes in response to roadway pricing.

Experience from a few parts of the world where some form of area-wide congestion pricing has been implemented suggests that transit ridership and mode share would in fact increase. One example is London, which implemented area-wide congestion pricing in the central part of the city in February 2003. The city charges a fee of £5.00 (approximately $8.50) for driving private automobiles in its central area during weekdays between 7:00 AM and 6:30 PM as a way to reduce traffic congestion and raise revenues to fund transportation improvements. Initial results suggest that the auto use during congestion charge times has dropped by nearly 20%, resulting in the auto mode share declining from about 12% to 10%.

The majority of drivers changing their travel patterns due to the congestion charge transferred to public transit. Bus ridership increased by 14% and subway ridership by about 1%.

The City of Singapore also has a similar area-wide pricing scheme which was implemented in 1975 and made fully electronic in 1999. Over time, the automobile mode share for trips to the central area has fallen from 56% to only 23%, with most people shifting to transit or carpooling.

In the Puget Sound area, the overall mode shift would likely be markedly less than observed in Singapore or even London for several reasons. First, these two examples are rather steeply priced "cordon" tolls, while our analysis assumes per-mile tolls that would vary with the level of congestion. In addition, the Pricing Focus Scenario assumes variable time-of-day pricing of all trips, at all times, within a four-county region. The other examples focused on weekday, predominantly work trips, into or out of a downtown area. It should also be pointed out that central London and Singapore already have high levels of both short and long haul transit service, higher auto costs, and the land use patterns to support high transit use. These factors make transit a better substitute for a personal auto than would likely be the case in the central Puget Sound region.

It is interesting to note that the transit mode share under the Pricing Focus Scenario would remain essentially unchanged relative to the 2025 Baseline Scenario. While there might be some expectation for the transit mode share to increase with value pricing (see The Effects of Pricing on Transit Usage on the previous page), the application of value pricing to every roadway in the region goes beyond the PSRC model's current capability. Therefore, the model may not capture all of the travel behavior changes associated with value pricing.

Transit Ridership Potential

The various scenarios examined fixed-guideway transit facilities in many corridors in the Puget Sound urban area. These facilities included commuter rail service on existing railroad lines, which are primarily oriented toward accommodating peak period travel, and high-capacity transit fixed-guideway facilities, which serve both peak period and all-day travel. The higher investment scenarios included transit facilities, which are proposed within PSRC's Metropolitan Transportation Plan and Sound Transit's Long Range Plan, as well as additional facilities that appeared promising based on the Unconstrained Transit Demand Analysis.

Figure 2-46 shows a relative comparison of daily ridership projected on the fixed-guideway transit facilities included in the Transit Focus Scenario and also shows total daily transit volumes crossing several screenlines in the Puget Sound urban area. Figure 2-46 shows medium to high levels of daily ridership on many of the fixed-guideway facilities, particularly those in King County. The commuter rail lines show relatively low levels of daily ridership, since their focus is peak period not daily travel. As can be seen from the screenline volumes, the highest ridership is expected in the corridors between Downtown Seattle and North King County/South Snohomish County and in the corridors between Downtown Seattle and East King County. The individual facilities with the highest ridership are the North Link light rail line and fixed-guideway facilities between Downtown Seattle and Downtown Bellevue via I-90.

Figure 2-47 shows comparisons of daily ridership for the Transit Emphasis Mixed Scenario. As shown, this scenario contains fewer fixed-guideway transit facilities than the Transit Focus Scenario. The two facilities in the Transit Emphasis Mixed Scenario that had relatively high levels of daily ridership, between Downtown Seattle and Shoreline and between Downtown Seattle and Downtown Bellevue, again show high levels of ridership. In addition, the South Link light rail line from Downtown Seattle to Sea-Tac also shows a high level of ridership in the Transit Emphasis Mixed Scenario. This is a reflection of the fact that in the Transit Focus Scenario, transit travel between SeaTac and Downtown Seattle was split between two fixed-guideway facilities, the South Link light rail line and a high-capacity transit line along the Duwamish to South Park, Burien and SeaTac. In the Transit Emphasis Mixed Scenario, the South Link light rail line now provides the only fixed-guideway service between SeaTac and Downtown Seattle.

Figure 2-48 shows comparisons of daily ridership for the Highway Emphasis Mixed Scenario. As shown, this scenario contains fewer fixed-guideway transit facilities than the Transit Emphasis Mixed Scenario or the Transit Focus Scenario. The highest level of daily ridership is found in the Link light rail corridor between Shoreline and Sea-Tac, which is consistent with findings in previous studies over the past 10-15 years. The next highest corridors are extensions north to Lynnwood and south to Federal Way, across the I-90 corridor to Bellevue, and corridors north and south of Downtown within the City of Seattle. Transit ridership is considerably lower across Lake Washington and at the King/Pierce County Line. This can be attributed to less transit service and more highway expansion in the Highway Emphasis Mixed Scenario.

Figure 2-46: Daily Transit Ridership at Selected Screenlines and HCT Corridors in the Transit Focus Scenario

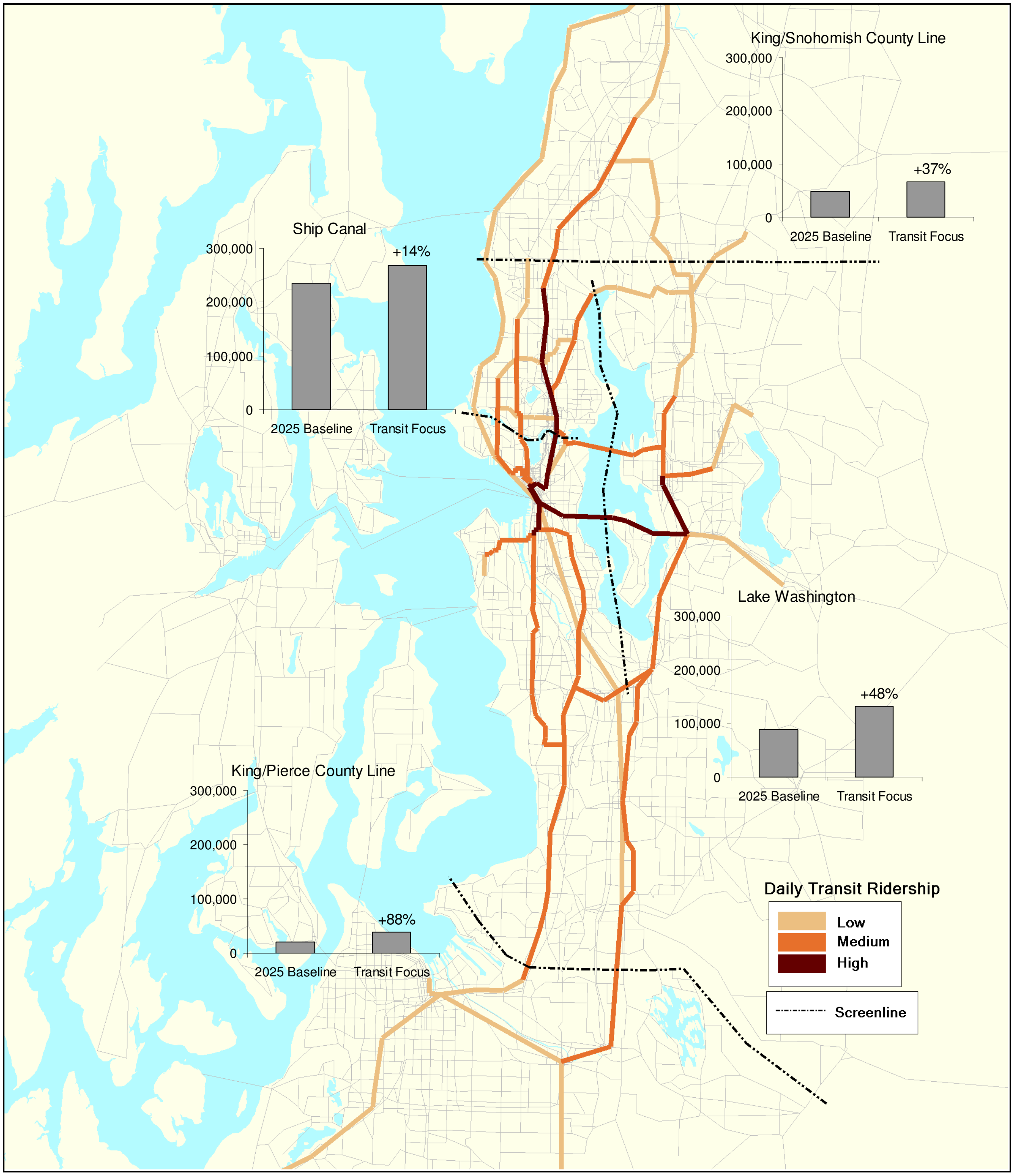


Figure 2-47: Daily Transit Ridership at Selected Screenlines and HCT Corridors in the Transit Emphasis Mixed Scenario

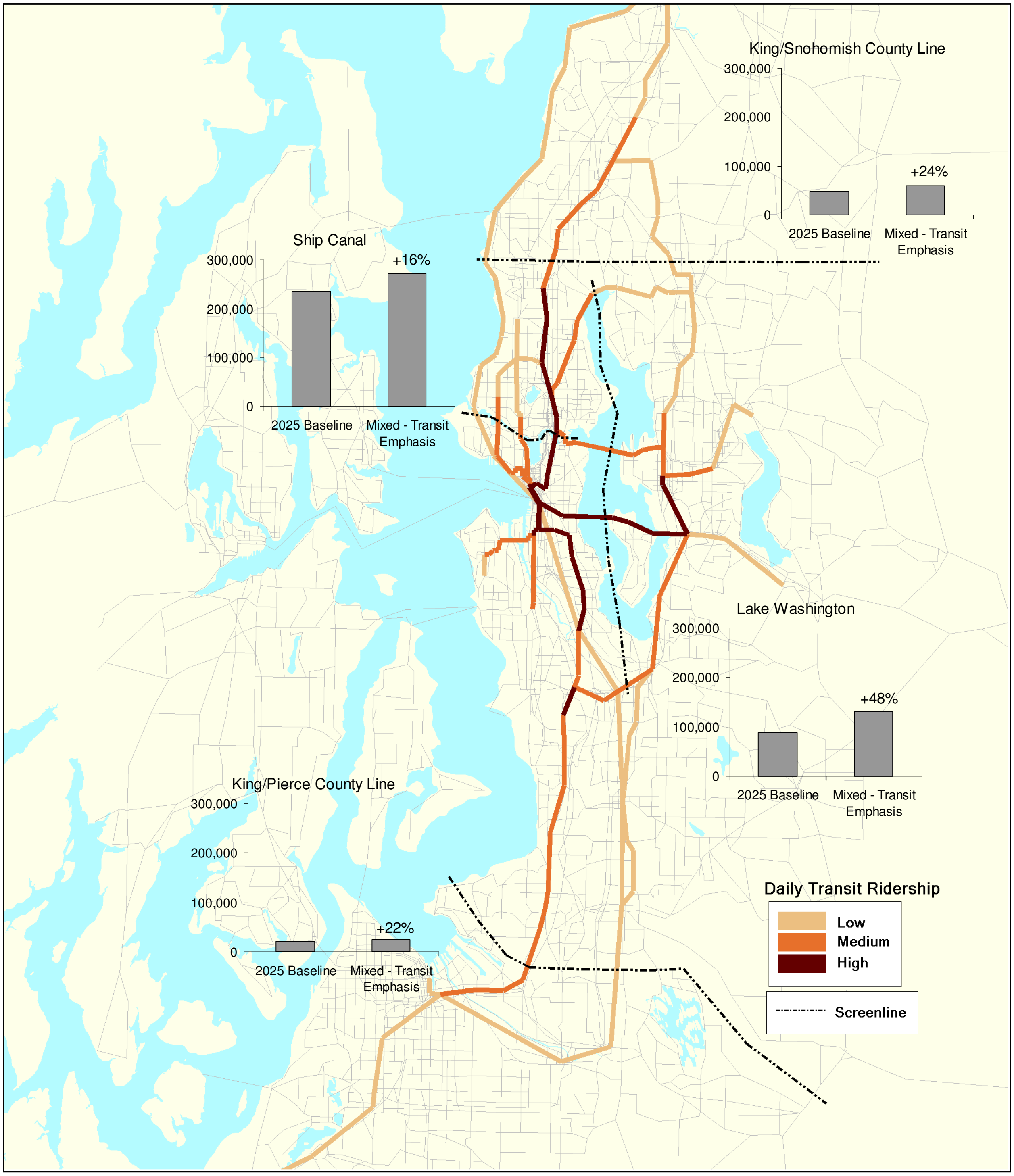
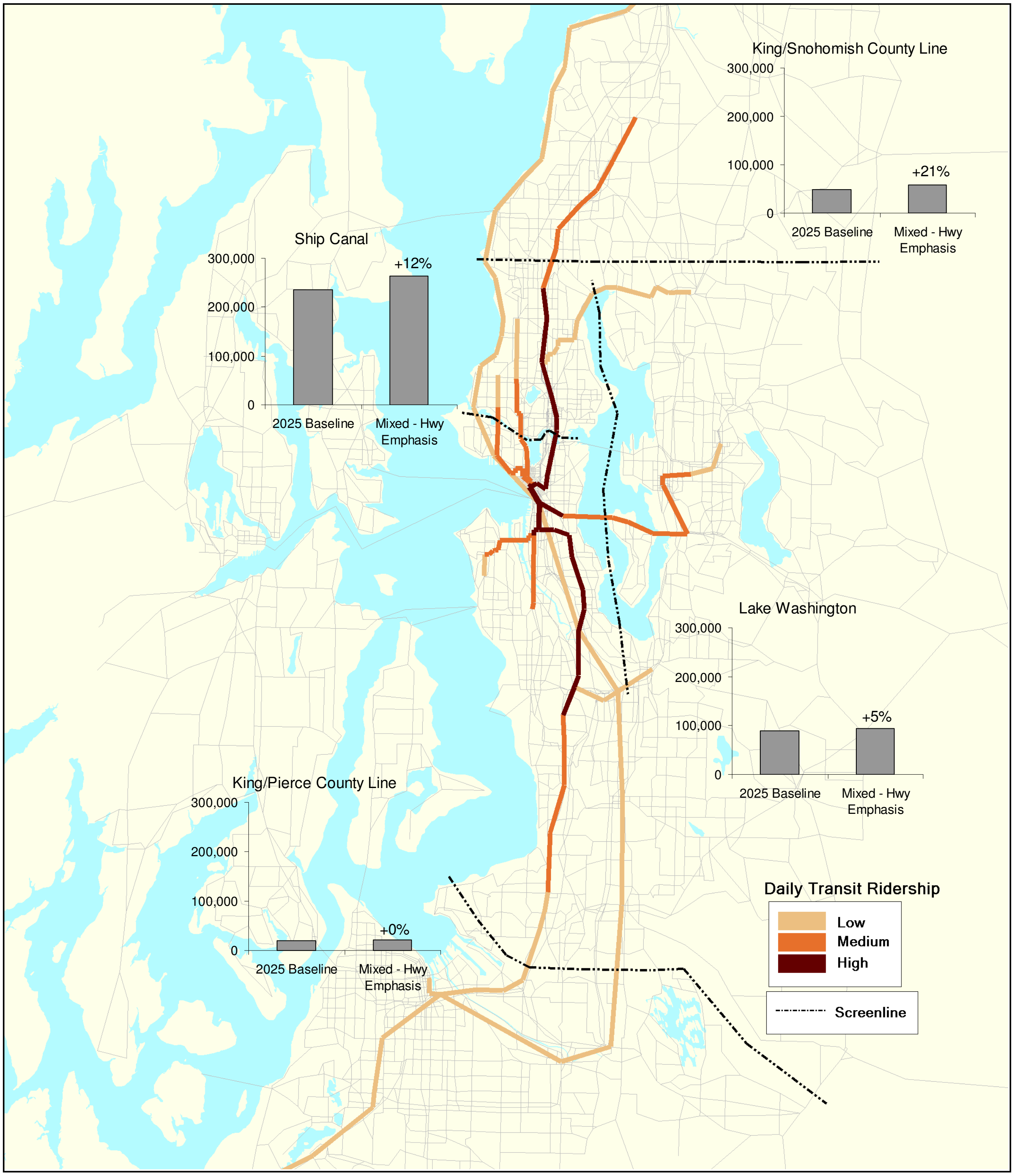


Figure 2-48: Daily Transit Ridership at Selected Screenlines and HCT Corridors in the Highway Emphasis Mixed Scenario



2.7 Cost Estimates

This section summarizes the cost estimates for the seven scenarios that go beyond maintaining the existing the existing system plus finishing the committed improvements included in the 2025 Baseline. Additional perspective on costs, particularly as they apply to the economic analysis, follows in the next section.

The cost estimates focused on the public costs for implementing, mitigating, operating and maintaining the infrastructure investments associated with each scenario, relative to the 2025 Baseline Scenario. Separate calculations were made for the following cost elements:

- Capital costs, including:
  - Design and construction;
  - Right-of-way / property takings;
  - Roadway environmental impact mitigation; and
- Operations and maintenance costs.

Capital costs are expressed as estimated ranges in constant 2003 dollars, in part to facilitate the economic analysis, but also because the detailed construction schedules required for producing year of expenditure estimates were not developed. All capital cost estimates were produced as ranges around expected values to account for estimation error and risk / uncertainty in producing future cost estimates. The cost range for highway and transit infrastructure and associated elements was assumed to range from –5% to +25% from the expected cost value.

> **Toll Collection Equipment and Facilities**
> The toll collection equipment and facilities costs for the two scenarios with pricing represent two exceptions to cost estimation process. Portions of the toll collection O&M costs were assigned the same -5% to +25% range as capital costs due to uncertainty in future tolling technology. In addition, a somewhat wider range on the high side (+30% to +50%) was applied to toll collection capital investment costs. These differing assumptions reflect a somewhat wider confidence interval / degree of uncertainty in developing toll collection-related cost estimates, particularly given the relatively rapid pace at which toll collection technology changes. The technologies assumed are currently either very limited in existing applications or the scope of their application is less extensive than proposed.

The annual operations and maintenance (O&M) cost estimates were developed to reflect yearly expenditures, including an annual factor for less frequent but recurring renewal and rehabilitation costs. With the exception of toll collection operations, annual O&M costs were not assigned ranges.

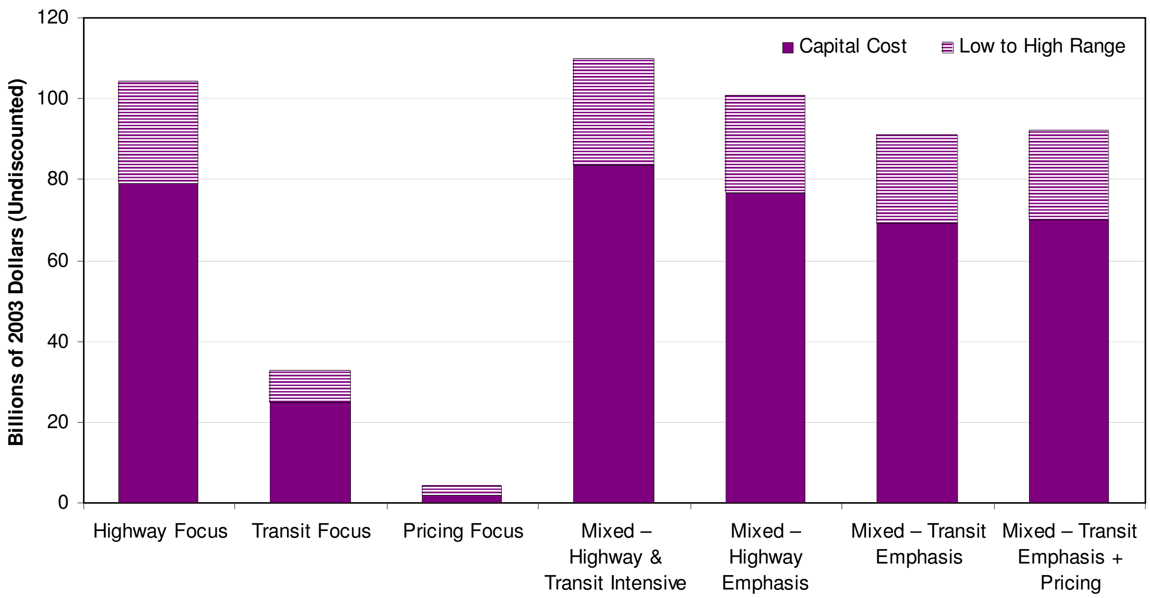
Capital Costs

Table 2-8 and Figure 2-49 collectively show the overall future capital cost ranges for the seven scenarios. With the exception of the Pricing Focus Scenario, the capital investments examined in this study would be in the tens of billions of current dollars. The Pricing Focus Scenario (which overlays dynamic roadway value pricing on the 2025 Baseline network using global positioning system and cellular data transmission technologies) would not involve major roadway infrastructure investment. The Transit Emphasis with Pricing Mixed Scenario would overlay tolls on selected freeway corridors. Conventional electronic toll collection technologies are assumed in this case (vehicle transponders and above-road transponder readers), and the incremental costs of this value pricing approach would be in the hundred million dollar range, rather than billions of dollars.

Table 2-8: Capital Cost Expected Values and Ranges by Scenario

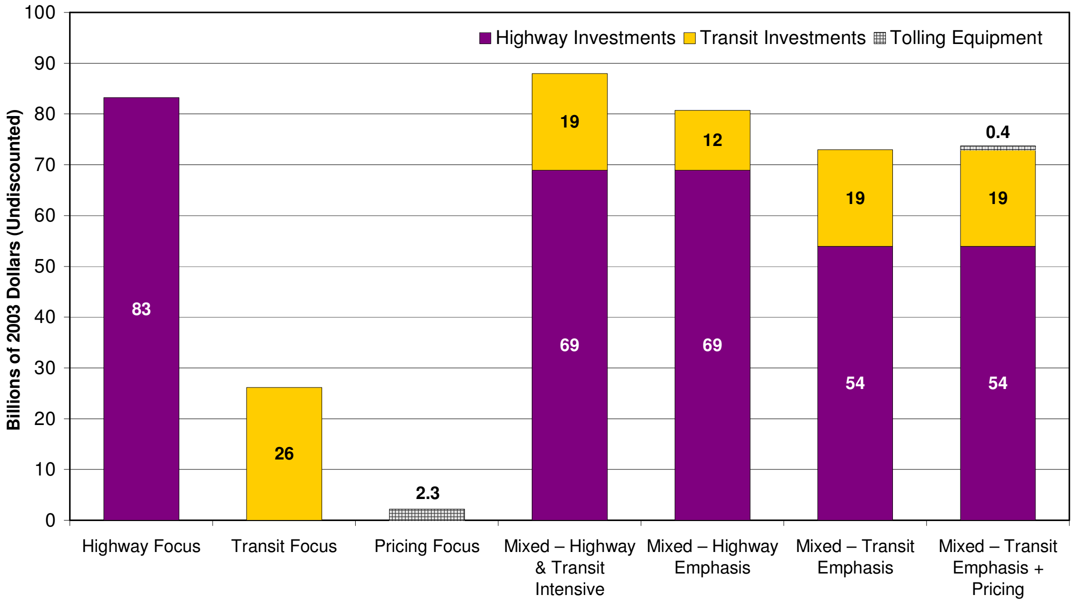
Scenario	Capital Implementation Costs in Constant Dollars*		
	Low End of Range	Expected Value	High End of Range
Highway Focus	$79.1 B	$83.2 B	$104.0 B
Transit Focus	$24.9 B	$26.2 B	$32.8 B
Pricing Focus	$2.0 B	$2.3 B	$3.4 B
Mixed – Highway & Transit Intensive	$83.5 B	$87.9 B	$109.9 B
Mixed – Highway Emphasis	$76.7 B	$80.7 B	$100.9 B
Mixed – Transit Emphasis	$69.3 B	$72.9 B	$91.2 B
Mixed – Transit Emphasis + Pricing	$69.6 B	$73.3 B	$91.7 B
* Billions of year-end 2003 dollars before present value discounting			

Figure 2-49: Capital Cost Ranges by Scenario (2003 $ in Billions)



It is useful to illustrate the magnitude and relative mix of investments by mode or application. The mixed scenarios emphasize different combinations of highway and transit investments, but even the mixed scenarios that emphasize transit include more dollars in absolute terms for highways. These relationships are shown in Figure 2-51, which depicts the capital cost expected values for each scenario's range segmented by investment type.

Figure 2-50: Capital Cost Expected Values by Investment Type (2003 $ in Billions)[8]



Components of Capital Costs

The capital costs shown in Table 2-8 and Figure 2-49 include the following three major components:

- Design and construction;
- Right-of-way / property takings; and
- Roadway environmental impact mitigation.

Each of these components is described below.

Design and Construction

Design and construction cost estimates were developed using models based on unit price estimates for 'typical' roadway sections, interchanges, and transit elements for light rail transit, bus rapid transit, commuter rail, buses, and park-and-ride lots. Models of interchange, roadway, and transit elements were developed and modified with input from WSDOT and local transit agencies to reflect area case histories. These cost models were applied to the highway and transit improvements on a segment-by-segment basis to compute the design and construction cost estimates.

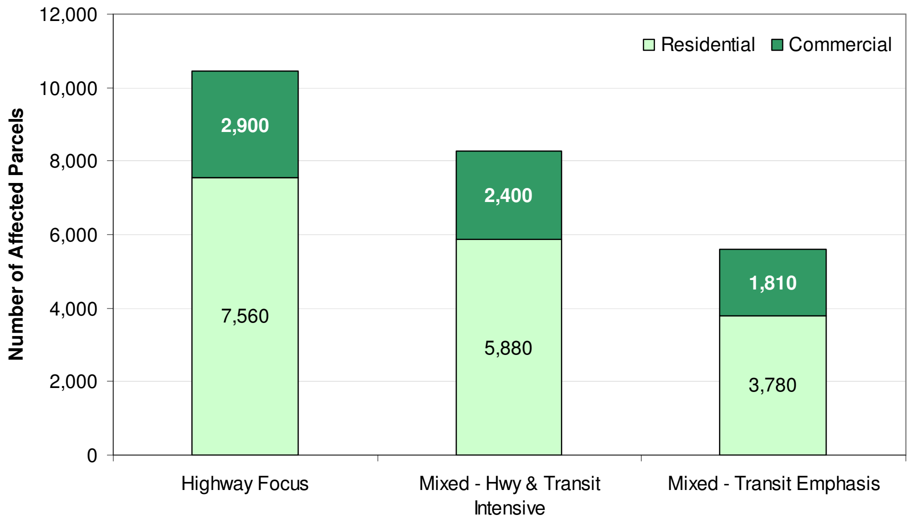
Right-of-Way / Property Takings

The amount of additional right-of-way that would need to be purchased was calculated based on the width of unused existing right-of-way, as determined from GIS data, and the additional width needed for the number of lanes that would be added over the length of each corridor. Figure 2-51 shows the total number of affected parcels; the affected parcels include properties that would

[8] Transit improvement costs do not include the acquisition of additional rights-of-way. Therefore, the actual transit improvement costs will be higher than shown here.

require either a partial or a full take, depending on the extent of the right-of-way needs. Estimates were only made for the Highway Focus Scenario, the Highway and Transit Intensive Mixed Scenario, and the Transit Emphasis Mixed Scenario; however, these three scenarios represent the three levels of highway investments that cover the full range of scenarios.

Figure 2-51: Impacts to Residential and Commercial Parcels



All scenarios, with the exception of the Pricing Focus Scenario, would potentially result in substantial right-of-way needs and property impacts. The greatest impacts would be associated with roadway-related improvements. The Highway Focus Scenario would affect an estimated 10,400 parcels, and the Highway Emphasis Mixed Scenario would potentially affect an estimated 8,300 parcels. The Transit Emphasis Mixed Scenario would potentially affect an estimated 5,200 parcels. Transit right-of-way needs were identified in specific corridors where only if the need was apparent. In most corridors, however, transit improvements were assumed to occur within existing transportation rights-of-way, usually on aerial guideways.

Potential Roadway Environmental Impact Mitigation Costs

Estimates were developed for the mitigation costs associated with potential wetland and stream impacts**.** In order to estimate the cost impacts of wetlands and streams, the project team used Geographic Information Systems (GIS) software to display the 2025 Baseline Scenario, the other scenarios, and the locations of known wetlands and streams in the study area. All scenarios, with the exception of the Pricing Focus Scenario, would have some impact to wetlands and streams. The greatest potential for impacts would be associated with highway-related improvements, although new transit maintenance facilities, stations, and park-and-ride facilities would also have the potential to affect wetlands and streams (in most corridors, transit improvements were assumed to occur within existing transportation rights-of-way, usually on aerial guideways). The Highway Focus Scenario would have the greatest potential for wetland and stream impacts, followed by the Mixed Highway Emphasis and the Highway and Transit Intensive Mixed Scenarios. Figure 2-52 and Figure 2-53 illustrate the potential estimated impacts to streams and wetlands used in developing cost estimates.

Figure 2-52: Potential Wetland Impacts

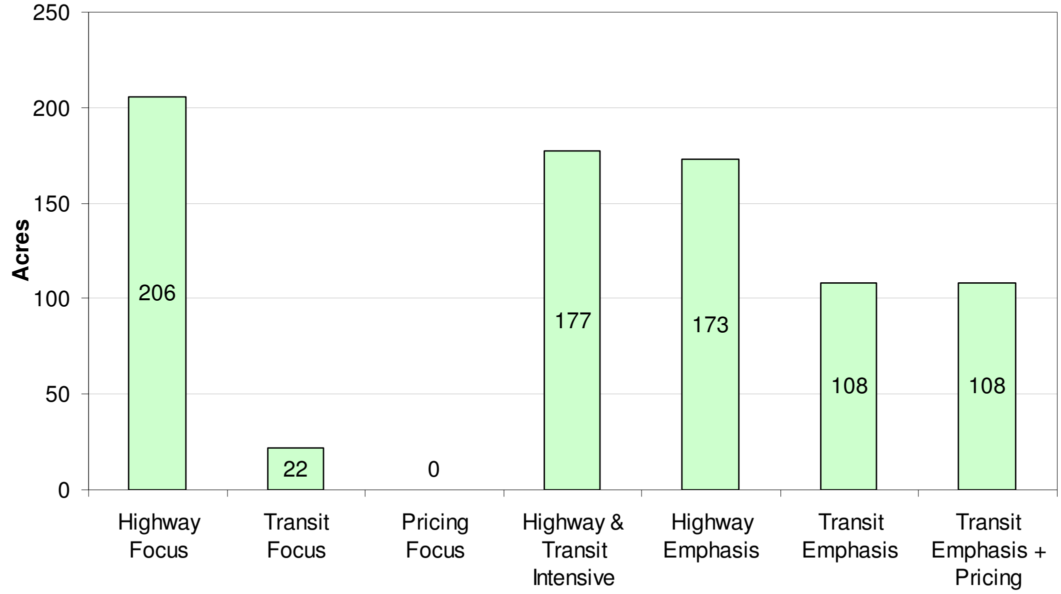
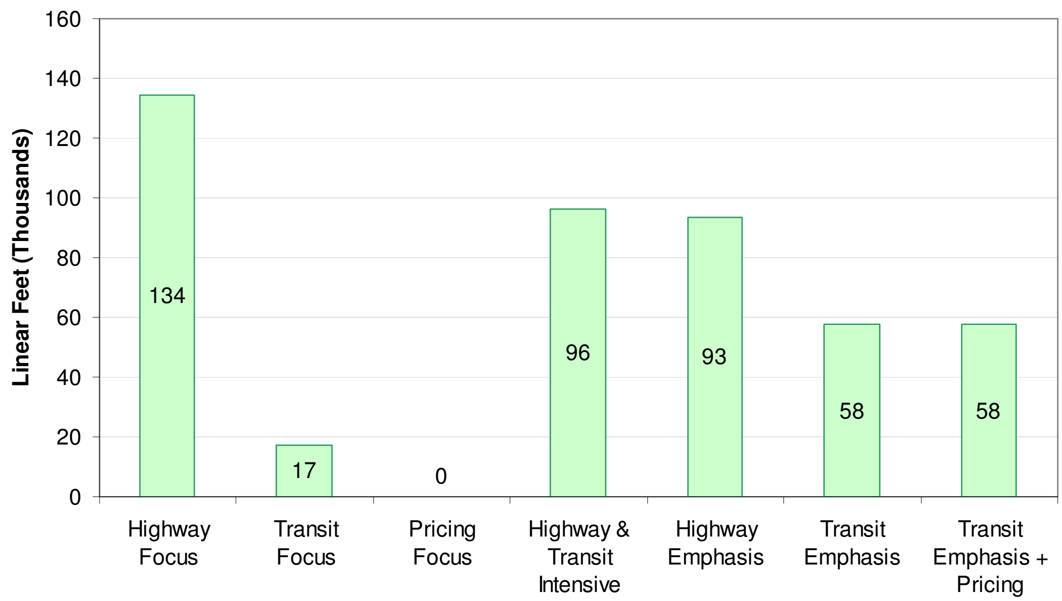


Figure 2-53: Potential Stream Impacts (Linear Feet)

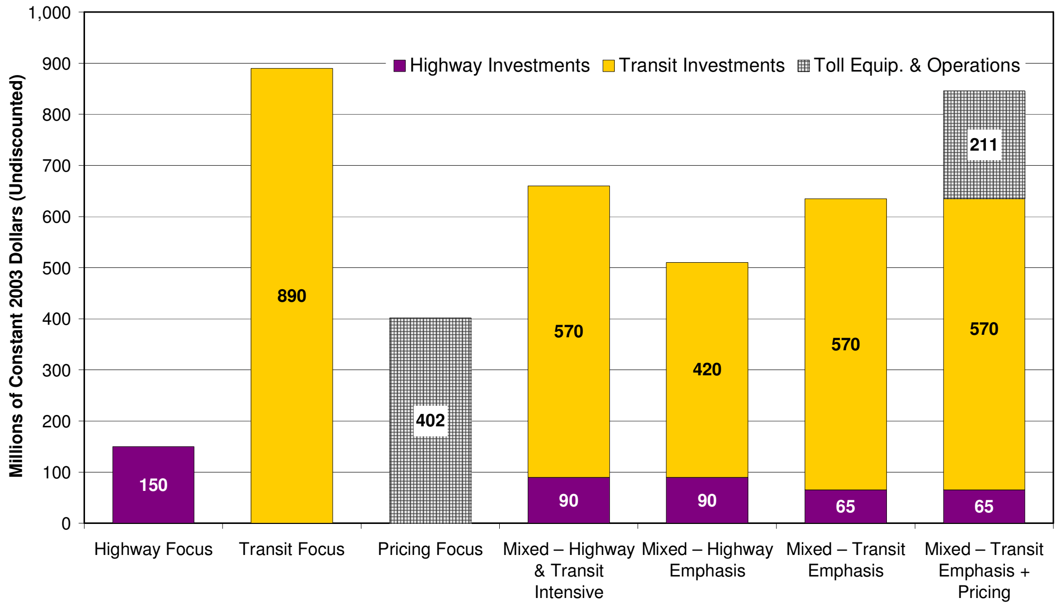


Operations and Maintenance Costs

Annual operations and maintenance (O&M) costs for each scenario are shown in Figure 2-54. These costs represent the incremental O&M activities of each scenario above and beyond those costs associated with the 2025 Baseline. Expenditures associated with the operation and maintenance of the 2025 Baseline highway and transit system are estimated to be in the range of $1.5 billion annually (2003 dollars)[9].

[9] Sources: HPMS 2003 Data from WSDOT HQ, WSDOT Ferry, WSDOT HQ Bridge Preservation, and Parsons Brinckerhoff.

Figure 2-54: Annual O&M Costs by Application / Investment Type (2003 $ in Millions)



For each scenario, O&M costs are categorized according to highway, transit and/or tolling-related investments. Note that transit O&M costs include ferries, and highway O&M costs include an annual factor for relatively infrequent renewal costs such as pavement rehabilitation.

2.8 Economic Analysis

An economic analysis of the various focus and mixed scenarios was conducted to assess each scenario's incremental benefits and costs relative to the 2025 Baseline Scenario. A combination of user and societal mobility benefits were assessed for the year 2025, as were the operations and maintenance costs for the new investments. Capital costs were assessed over a construction period proportional to the total investment size, and then annualized by estimating their one-year equivalent lease payment to compare them with the other annual amounts. All benefits and costs occurring at future points in time were expressed in constant 2003 dollars. This avoided the need to make inflation projections, which when applied equally to benefits, costs and the discount rate assumption, would have no bearing on the analysis outcome.

A more detailed discussion of the economic benefit-cost analysis methodology can be found in Chapter 1 and in the *Benefit-Cost Analysis Methodology Technical Memorandum* (Parsons Brinckerhoff, November 2004) included as Appendix A.

Cost

According to standard benefit-cost analysis practice, costs are defined as the public costs for implementing, mitigating, operating and maintaining the infrastructure investments associated with each scenario, relative to the 2025 Baseline Scenario. Any other costs (i.e., those borne by travelers) are considered in the assessment of benefits as disbenefits or negative benefits. For example, an increase in user travel costs is measured as a deduction to the benefits that user receives rather than as an increase to the infrastructure costs.
Capital investment costs are expressed as estimated ranges in constant 2003 dollars, as summarized in the previous section. These cost ranges were then annualized – converted to their

equivalent annual lease payments – to facilitate combining them with annual O&M costs for direct comparison with annual benefits in 2025. Annual operations and maintenance (O&M) costs reflect yearly expenditures for 2025 and include an annual factor for less frequent but recurring renewal costs, but were not assigned ranges.

Table 2-8 in the preceding section shows the overall future capital cost ranges, including the expected values, for the seven scenarios. Table 2-9 below shows the expected values within the range, and their associated annualized amounts (equivalent annual lease payments) along with annual O&M costs. All values are in constant 2003 dollars before present value discounting.

Table 2-9: Capital Cost Total and Annualized Expected Values and Annual O&M Costs

Scenario	**Capital Implementation Costs in Constant Dollars***		
	Total Expected Value (Range "Midpoint")	Annualized Value (Equivalent Lease Payment)	Annual O&M Costs
Highway Focus	$83.2 B	$4.51 B	$150 M
Transit Focus	$26.2 B	$1.59 B	$890 M
Pricing Focus	$2.3 B	$0.17 B	$402 M
Mixed – Highway & Transit Intensive	$87.9 B	$4.76 B	$660 M
Mixed – Highway Emphasis	$80.7 B	$4.32 B	$510 M
Mixed – Transit Emphasis	$72.9 B	$3.88 B	$635 M
Mixed – Transit Emphasis + Pricing	$73.3 B	$3.91 B	$856 M

* Billions (B) / Millions (M) of constant year-end 2003 dollars before present value discounting

Benefit

The economic analysis evaluated mobility benefits for the 2025 analysis year, divided into two main categories:

User benefits

- Personal travel benefits expressed as the dollar value of travel time and out-of-pocket cost savings by autos and transit users; and
- Commercial travel benefits expressed as the dollar value of travel time and operating expense savings.

Societal benefits

- Economic benefits of improved safety/accident reduction, and the associated avoidance of fatalities, injuries and property losses;
- The associated mobility benefits of reducing non-recurrent incident congestion delay; and
- Reductions in auto ownership costs (e.g., depreciation) resulting from reduced auto use.

User benefits are so grouped because they reflect benefits accruing directly to system users of all

Benefits Range

Similar to the capital cost estimates, a range was applied to the total estimated benefits to account for some of the uncertainty and measurement error in assessing and valuing benefits. In this case, a symmetrical range of +/- 20% about the expected benefit amounts was applied to each scenario. The percentage range used reflects the majority opinion of the study's expert panel.

User Benefits or User Costs?

Travelers tend to consider their own "costs" in making travel decisions. User costs represent travel time and those monetary "out-of-pocket" costs considered in making an individual trip (e.g., gas and oil, transit fares and tolls, but not fixed costs such as insurance or license fees). A reduction in these user costs produced by one of the analysis scenarios results in user benefits relative to the 2025 Baseline. Travel time savings tend to be the primary component of user benefits. However, it is possible for a scenario to increase overall user costs, at least for some users. Net increases in user costs were treated as deductions to the benefits (disbenefits) rather than as increases to the scenario cost components — the construction and O&M costs of a scenario's investments.

modes, and they represent the majority of the benefits quantified. Societal benefits capture the more indirect mobility benefits accruing to all of society, including benefits to non-users. Societal benefits are driven off changes in overall vehicle miles traveled (VMT). Overall changes in VMT per vehicle affects annual depreciation costs in the case of auto ownership, while relative changes in VMT between facilities with different accident rates affect safety benefits/accident loss costs. For scenarios that increased vehicle miles of travel, the indirect effect of changes in travel behavior resulted in societal disbenefits, potentially manifest as an increased number of accidents or higher auto ownership costs, relative to the 2025 Baseline. However, such indirect disbenefits were more than overshadowed by the direct user benefits, of which time savings is the primarily component.

For many reasons, some benefits/disbenefits do not lend themselves to monetary quantification within the framework of this study. Examples include the long-term health-related value of changes in vehicle emission levels and concentrations, and the effect of business location decisions on regional employment and economic activity that is affected by traffic congestion. A thorough discussion of the benefits can be found in Appendix A.

Economic Analysis Metrics

The total annual benefit and cost ranges, expressed in discounted present values, represent two key metrics that can be collectively used to compare 2025 annual benefits with the annualized costs for each scenario. Additional metrics were developed to express and compare various subsets of the benefits on a per trip basis, both in aggregate and by various travel modes/trip types. These metrics illustrate how certain benefits are distributed (before present value discounting). Finally, a metric was prepared that simply indicates the total annual person hours of auto delay savings per $1 million of total capital investment.

The following sections present the results for each of these economic analysis metrics and discuss various issues with their interpretation.

Metric: Benefit and Cost Present Value Ranges

To appropriately make comparisons between the monetary benefits and costs of each scenario relative to the 2025 Baseline, it is necessary to consider these amounts as discounted present values. Because future benefits and costs were already estimated in current dollars, a real discount rate of 3.5% was used to value future benefits and costs in present worth terms.[10] Additional discussion of present value discounting is included in the Methodology section of Chapter 1 of this report and in Appendix A.

Single benefit-cost (B/C) ratios and/or net present values (NPVs) for each of the seven scenarios were not formally calculated and presented for the following reasons:

- The benefits and costs are expressed as ranges, which would result in a continuum of B/C ratios and NPVs rather than single values; and
- The study objectives focus on analyzing large groups of projects that focus on how effective they are in reducing regional congestion. This contrasts with the more typical application of benefit-cost methods, which evaluate alternatives for a single project or prioritize the ranking of different individual projects within a financially constrained budget.

Table 2-10 presents the expected benefit and cost values as well as their range low- and high-endpoints, expressed in constant 2003 dollars after present value discounting.

[10] A real discount rate excludes an inflation component and applies when values are in constant dollars.

Table 2-10: Low, High and Expected Annual Values for Benefits and Costs after Discounting

Scenario	Discounted Present Values					
	2025 Annual Benefits Range			Annualized Capital + O&M Costs Range		
	Low End	Expected Value	High End	Low End	Expected Value	High End
Highway Focus	$1.5 B	$1.8 B	$2.2 B	$2.5 B	$2.8 B	$3.7 B
Transit Focus	$0.48 B	$0.60 B	$0.73 B	$1.2 B	$1.3 B	$1.5 B
Pricing Focus	$0.74 B	$0.93 B	$1.1 B	$0.26 B	$0.27 B	$0.33 B
Mixed – Highway & Transit Intensive	$1.6 B	$2.0 B	$2.4 B	$2.9 B	$3.0 B	$3.9 B
Mixed – Highway Emphasis	$1.5 B	$1.9 B	$2.3 B	$2.6 B	$2.7 B	$3.5 B
Mixed – Transit Emphasis	$1.0 B	$1.3 B	$1.6 B	$2.3 B	$2.4 B	$3.1 B
Mixed – Transit Emphasis + Pricing	$1.7 B	$2.1 B	$2.5 B	$2.4 B	$2.5 B	$3.3 B

Note: Benefits and costs are expressed as ranges around future expected values, expressed in constant 2003 dollars inclusive of present value discounting. Benefits exclude non-quantifiable congestion relief impacts, including the effects on business location decisions and economic activity.

Figure 2-55 graphically presents the annualized cost range for each scenario. Figure 2-56 presents the 2025 annual benefits range for each scenario.

Figure 2-55: Annualized Cost Ranges in Discounted Present Values

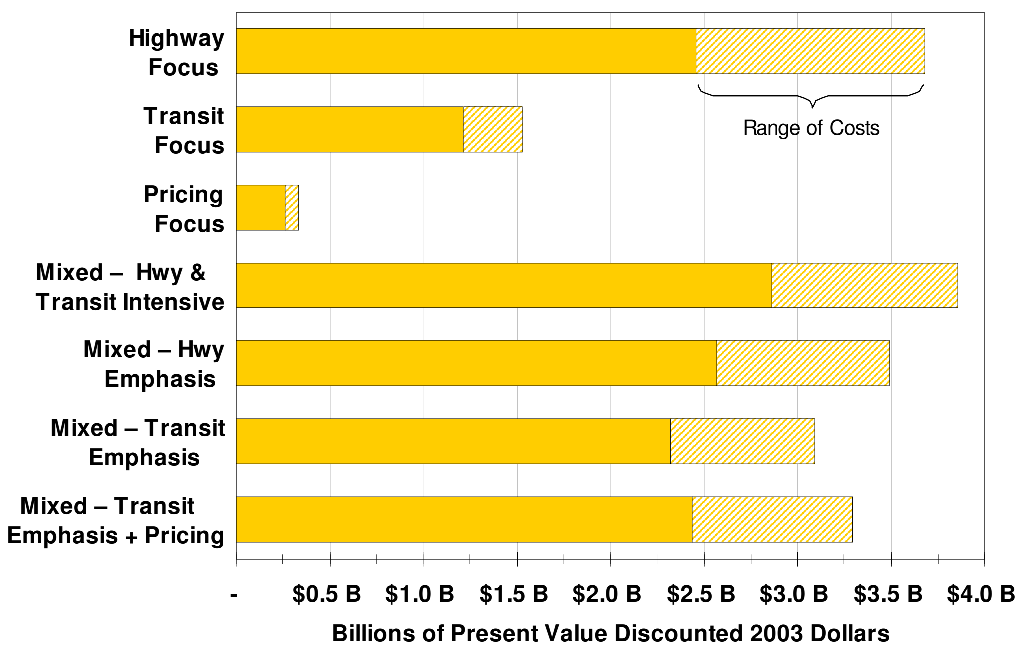
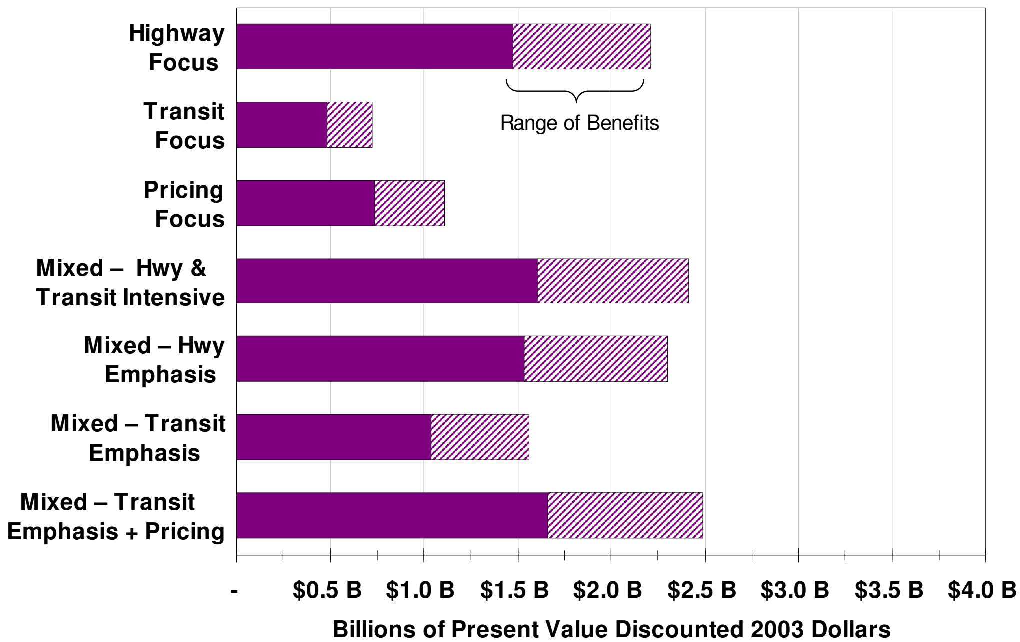


Figure 2-56: Annual Benefit Ranges in Discounted Present Values



Note: Benefits exclude non-quantifiable congestion relief impacts, including the effects on business location decisions and economic activity.

A comparison of Figure 2-55 and Figure 2-56 suggests that, for the most part, the annualized costs of the associated scenarios exceed the annual economic benefits in 2025 over the ranges estimated. For the scenarios evaluated for the central Puget Sound region, there are a few points that should be considered in interpreting these results.

The Scale Effect of Scenario Investments

First, a great deal of the highway and transit infrastructure within the region is relatively costly due to the requirements for structures, tunnels, right-of-way and other challenges surrounding the expansion of capacity in a mature built environment. Second, the levels of infrastructure investment in all but the Pricing Focus Scenario are extraordinarily large by any standard. Even the "smallest" of the capacity investment scenarios, the Transit Focus Scenario, would involve

Why do benefits exhibit diminishing returns to scale, but costs do not?

Each dollar of infrastructure investment does not produce equal benefit returns. For a multi-billion dollar investment scenario, expenditures that address specific chokepoints or highly congested areas can produce a relatively high benefit per dollar invested. With these improvements in place, additional investments may produce diminishing benefit returns, either because they address relatively less problematic areas or because a portion of what would have been their independent benefits gets captured by other, preceding investments. With eventual diminishing benefits for each additional dollar invested, it is likely that the infrastructure investment scenarios tested in this study are too extensive to produce measurable benefits in excess of the significant capital and O&M costs.

On the other hand, the cost estimates prepared for this study were based on fixed unit cost values for items such as labor and certain raw materials, as well as for aggregated components, such as a lane-mile of freeway pavement. These building block prices took into account that they would be applied to combinations of large projects, but were not varied with the level of scenario investments. In other words, unit costs were the same regardless of whether applied to $0.1 billion or $50 billion of highway infrastructure. In reality, $50 billion of investment might actually be associated with higher unit costs of construction than $0.1 billion. Too much investment construction occurring at the same time can adversely affect the availability and cost of obtaining labor and materials in the local construction market. As the market "overheats", all prices would rise. In the absence of detailed construction schedules and knowledge of future market conditions, constant returns to scale were assumed for the constructions cost estimates employed for this study.

expenditures in excess of $25 billion. These large scenarios lead to a “scale effect” by which benefits exhibit diminishing returns, but costs do not.

Put another way, there is a point after which additional investments yield fewer and fewer benefits because the investments that preceded them solved the more pressing congestion problems and captured larger proportional shares of system mobility benefits. However, the costs for these additional investments do not diminish per unit of constructed infrastructure. As a result, the tremendous scale of the study’s scenarios reduces the likelihood of generating overall mobility benefits in excess of their significant capital and O&M costs.

Nonetheless, given that sizable benefits are generated in all of the investment scenarios, it likely the case that one or more subsets of each scenario — groups of selected highway and/or transit investments — would evaluate as cost-beneficial, exhibiting present-value benefits in excess of associated costs.

Other Benefits and Measurement Issues

The assessment of benefits focused on the user benefits accruing directly to the personal travelers and commercial vehicles using the transportation system, plus certain indirect mobility benefits which accrue to all of society. Benefits such as increased overall economic activity, employment gains and net business in-migration resulting from an improved transportation system were not included. Not only are these induced benefits difficult to quantify, but also in many cases they may merely represent a capitalization of the user benefits already accounted (the time savings accruing to users are why economic activity increases in an area). In addition, a guiding principle of this study was a constant set of population, employment and land use assumptions across the scenarios. These assumptions make it difficult to yield net induced economic impacts beyond user benefits, as an increase in economic activity in one area would likely be offset by a decrease in another area resulting from changing travel patterns without a change in population or employment.

Nonetheless, there are several economic benefits that escape estimation with the existing modeling tools, yet would likely occur. Reduced congestion will free up time and some of that time savings will be reflected as productivity gains, resulting in higher economic activity and overall income. Higher productivity and an efficient transportation system would likely increase the region's trade with other parts of the nation/world, and may attract additional businesses to the region. Improved travel time reliability will also contribute to these gains, and represents a direct benefit to users that is separate from, and not captured by, travel time savings resulting from the transportation improvements.

Highway and Transit Focus Scenarios

The Highway Focus Scenario generates more benefits per dollar invested than does the Transit Focus Scenario, as evidenced by a comparison of Figure 2-55 and Figure 2-56. Both the Highway Focus and Transit Focus Scenarios were intended to be far reaching, singular mode portfolios of investments. The fact that the cost magnitude of the former is over three times greater than that of the latter, combined with the diminishing returns of benefits, suggests that there would be a subset of the Highway Focus Scenario equivalent in capital cost to the Transit Focus Scenario that would generate greater benefits, and may even yield net benefits in excess of costs. However, neither of these extensive single mode investment scenarios appears to be particularly advantageous from a benefit-cost perspective. In addition, potential inter-modal synergies cannot be optimized with investments in only one mode. For example, bus transit would benefit from improvements under the

Highway Focus Scenario, but this scenario assumes no additional bus service to meet/facilitate any potential increase in transit demand caused by improved travel times.

One challenge of the Transit Focus Scenario is that most of the benefits it would create accrue to a relatively small proportion of travelers. While this scenario generates significant benefits on a per-trip basis (see Table 2-11), the travel demand model predicts that transit users will make up less than 7% of weekday total personal travel. Ongoing costs for transit operations and maintenance are also higher per dollar of capital investment than for highways.

Pricing Focus Scenario

While the Pricing Focus Scenario is the only scenario tested that appears to be uniformly cost-beneficial, it is also perhaps the least well-defined of the scenarios, making it difficult to comprehend and to compare with those that make infrastructure investments.

The Pricing Focus Scenario has substantially lower overall annualized costs because its capital investment is limited solely to toll collection and operating equipment. This holds true despite its relatively high annual O&M costs associated with the operation, customer service, administration, and enforcement activities of widespread roadway value pricing.

Applying variable value pricing to all freeways and major arterials in the region necessarily alters the travel behavior of some persons, potentially reflected in shorter trips, different (lower toll) routes, different (lower toll) times of travel, change of mode to toll-free transit or 3+ HOV, etc. This shift in behavior is intended to keep roadways operating at optimal efficiency (high throughput) by collectively removing a small proportion of travel off of congested roadways during times of high demand. The result is substantial time savings benefits and operational efficiencies for the remaining users in exchange for the tolls paid.

This study assumes only that the toll revenues generated would be put to a beneficial public use. It does not prescribe how the available revenues (net of operations costs) would be spent. It is conceivable that some of the revenues could be used to offset the costs borne by those who alter their travel in response to tolls, including, for example, the provision of toll credits for those that opt to drive at low demand times of day. Similarly, revenues could potentially be used to pay for alternative modes, such as additional transit service. And, there is certainly the prospect of paying for capacity improvements, though this was not explicitly considered as part of this value pricing only scenario. There are many options for putting toll revenues to beneficial use, and consideration of value pricing would need to consider how best to distribute the proceeds to achieve an appropriate and equitable distribution of benefits and costs.

A comparison of Figure 2-29 (Total Vehicle Hours of Delay) with Figure 2-56 above suggests that the Pricing Focus Scenario would provide similar delay savings to both the Highway Focus Scenario and the Highway Emphasis Mixed Scenario. Yet Figure 2-56 indicates that the overall benefits of the Pricing Focus Scenario (which are largely delay savings) would be notably smaller than these other scenarios. This apparent inconsistency can be explained by considering how the benefits are generated. For the scenarios with highway capacity investments, travel patterns would not be greatly changed, and thus, the majority of delay savings represent economic benefits. In contrast, a per-mile value pricing scheme tends to induce users to change their destinations to make trips shorter in order to minimize costs. Much of the "delay savings" from value pricing would occur because trips would be shorter to begin with (although the reduction in travel would also lower congestion and thus, reduce delay via improved speeds). The problem, however, is that time saved for a shorter trip may not represent the traveler's "first choice" of destination, and thus, should not be fully counted as an economic benefit. It is because the assessment of user benefits for the Pricing Focus Scenario takes into account both time saving benefits and the disbenefits associated with changing trip destination that the benefits shown in Figure 2-56 are not commensurate with the "delay savings" shown in Figure 2-29.

Mixed Scenario – Highway and Transit Intensive

The preceding results suggest that the "mixed" scenarios could be more cost-beneficial than single-mode investments since they would potentially include the more productive components of each modal improvement evaluated in the focused scenarios. The Highway and Transit Intensive Scenario sets the ceiling levels of modal investment for the other mixed scenarios. It combines the majority of the investments of the two focused scenarios – 83% of the Highway Focus and 73% of the Transit Focus levels of investment, in terms of dollars of expenditure. Overall, this amounts to 106% of the Highway Focus Scenario expenditures, with the investment in highway improvements totaling more than 3.5 times the corresponding level of transit investments. While the benefits are also higher than either of the two modal-focused scenarios, the overall scale of this mixed scenario is still too large to be cost-beneficial.

Mixed Scenario – Highway Emphasis

This scenario holds the level of highway investment at 83% of the Highway Focus Scenario, but drops the level of transit investment to 45% of that of the Transit Focus Scenario. By scaling back the level of highway and transit investments to some of the more productive components, the Highway Emphasis Mixed Scenario generates more overall benefits at a lower cost than the Highway Focus Scenario. Moreover, it also delivers more benefits per dollar of cost than the Transit Focus Scenario (and for that matter more benefits per dollar of cost than the other two mixed scenarios without value pricing). This suggests that a more careful selection and scaling of the most productive improvements would yield benefits that exceed the costs.

Mixed Scenario – Transit Emphasis

The Transit Emphasis Mixed Scenario holds the level of transit investment at 73% that of the Transit Focus Scenario, while scaling back the level of highway investment to 65% that of the Highway Focus Scenario. The term "transit emphasis" is relative, as the level of highway investment in this scenario is still more than 2.8 times that of transit capital expenditures. Overall, this scenario's level of expenditure approaches that of the Highway Emphasis Mixed Scenario, but generates disproportionately fewer benefits. Within these ranges of investments by mode, highway investments would appear to be benefiting more travelers and generating more benefits per dollar invested.

Mixed Scenario – Transit Emphasis with Pricing

The Transit Emphasis with Pricing Mixed Scenario adds variable freeway tolls to the Transit Emphasis Scenario. As shown in Figure 2-55 and Figure 2-56, the level of benefits and costs are much better aligned than for the same scenario without value pricing, demonstrating the potential synergies of selective value pricing with capacity investments. In this case, variable value pricing helps to better match demand with available capacity during peak times to improve the operational efficiency of the freeway system. By reducing SOV use for some discretionary trips and shifting other SOV trips into toll-free carpools and transit, the addition of value pricing — in combination with capacity improvements — enhances traffic flows and generates tangible delay savings to all system users, including transit.

Unlike the Pricing Focus Scenario, the extent of value pricing in this mixed scenario is limited to the freeway system. While this provides more unpriced choices and generally lower overall trip costs, there will still be some travelers who do not particularly benefit from value pricing, either because the value of their individual time and travel cost savings are not commensurate with the toll cost, or because value pricing has caused them to travel to a “second best” destination in order to save on toll costs. Potential inequities in the distribution of user benefits may be mitigated depending on how the net revenues from tolling would be invested or otherwise put to some beneficial use on behalf of society. The options for the revenues are many, and consideration of value pricing would need to consider how best to use the proceeds to achieve an appropriate and equitable distribution of benefits and costs.

Metric: User Benefits per Person Trip by Mode/Trip Type

Aside from comparing overall benefits and costs, it is interesting to examine how user benefits generated per trip varies across travel modes and scenarios. This analysis metric considers user benefits only — those changes in travel time and out-of-pocket costs experienced directly by travelers — on a per trip basis, both in aggregate and by selected travel modes or trip types. Combined with mode share estimates, this metric helps to illustrate how certain benefits are distributed.

Table 2-11 lists the user benefits per trip. These results are provided before present value discounting, though the relative relationships would be identical for their discounted present values. For each scenario, Table 2-11 lists the expected 2025 *user benefits per person trip* for auto and transit person-trips, for a composite measure of user benefits per trip across all types of personal travel, and for user benefits per trip accruing to commercial vehicle travel. The benefits are expressed in constant 2003 dollars based on the expected values (i.e., range midpoints) before present value discounting.

Table 2-11: User Benefits per Person Trip by Mode / Trip Type (Expected Values)

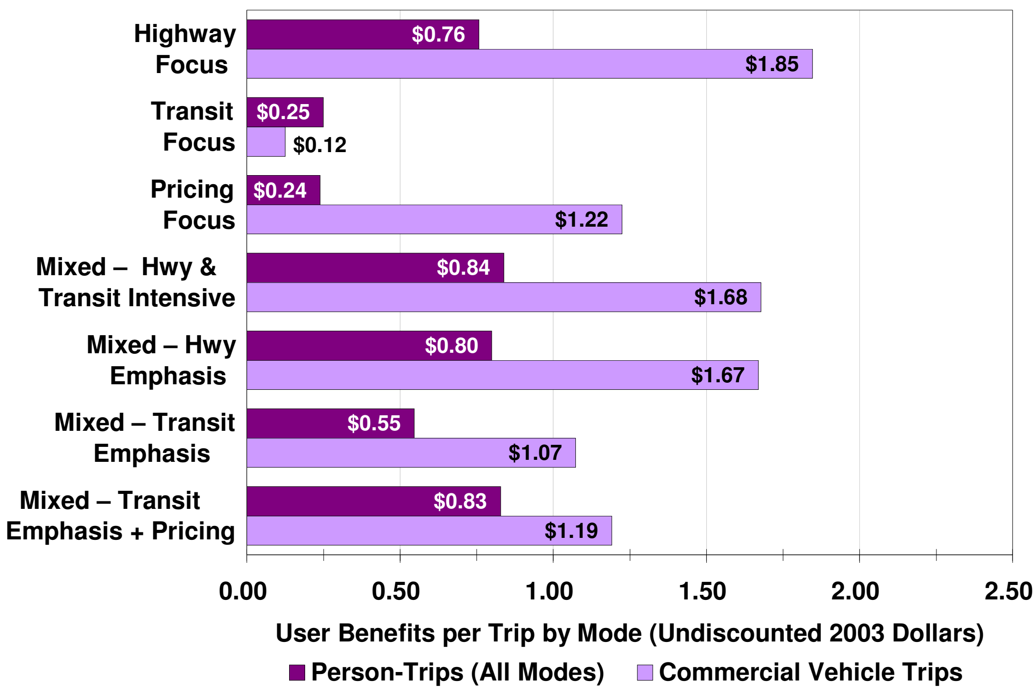
Scenario	**2025 Average Daily User Benefits***					
	Personal Travel					**Commercial Travel**
	Auto		**Transit**		**Total**	
	User Benefits per Person-Trip	Mode Share	User Benefits per Person-Trip	Mode Share	User Benefits per Person-Trip	User Benefits per Vehicle Trip
Highway Focus	$0.80	94.4%	$0.07	5.6%	$0.76	$1.85
Transit Focus	$0.07	93.6%	$2.93	6.4%	$0.25	$0.12
Pricing Focus	$0.25	94.5%	$0.13	5.5%	$0.24	$1.22
Mixed – Highway & Transit Intensive	$0.76	93.9%	$2.04	6.1%	$0.84	$1.68
Mixed – Highway Emphasis	$0.76	94.0%	$1.50	6.0%	$0.80	$1.67
Mixed – Transit Emphasis	$0.44	93.8%	$2.15	6.2%	$0.55	$1.07
Mixed – Transit Emphasis + Pricing	$0.73	93.8%	$2.23	6.2%	$0.83	$1.19

* Year 2025 range midpoint expected values in 2003 dollars before present value discounting for User Benefits only (includes travel time and out-of-pocket cost savings acrruing to users and excludes other indirect or societal benefits).

Table 2-11 also summarizes the transit and auto mode shares to provide a sense of perspective. For example, the Transit Focus Scenario would deliver an average user benefit of $2.93 per transit person-trip, but transit trips are estimated to comprise only 6.4% of all personal travel. In the same scenario, auto users would enjoy average benefits of only $0.07 per person-trip, yet comprise the vast majority of all personal travel. As a result, the Transit Focus Scenario would provide composite average benefits of $0.25 per person-trip (all modes).

Figure 2-57 graphically depicts the last two columns of data shown in Table 2-11 above. Essentially, it compares the composite average user benefits per person-trip for personal travel with the average user benefit per vehicle-trip for commercial travel. The values for each scenario are relative to the 2025 Baseline Scenario. The higher value of time assigned to commercial vehicle trips would result in greater benefits per trip in six out of the seven scenarios analyzed. Only the Transit Focus Scenario, by excluding any highway investments, would yield greater benefits per trip for personal travel than for commercial travel. Here, transit investments create significant user benefits primarily for transit patrons. However, this somewhat skewed impact has the effect of lifting the average benefit realized across all modes of personal travel such that is exceeds the benefits experienced by commercial vehicle trips.

Figure 2-57: User Benefits per Trip by Personal and Commercial Travel (Range Midpoint Values)



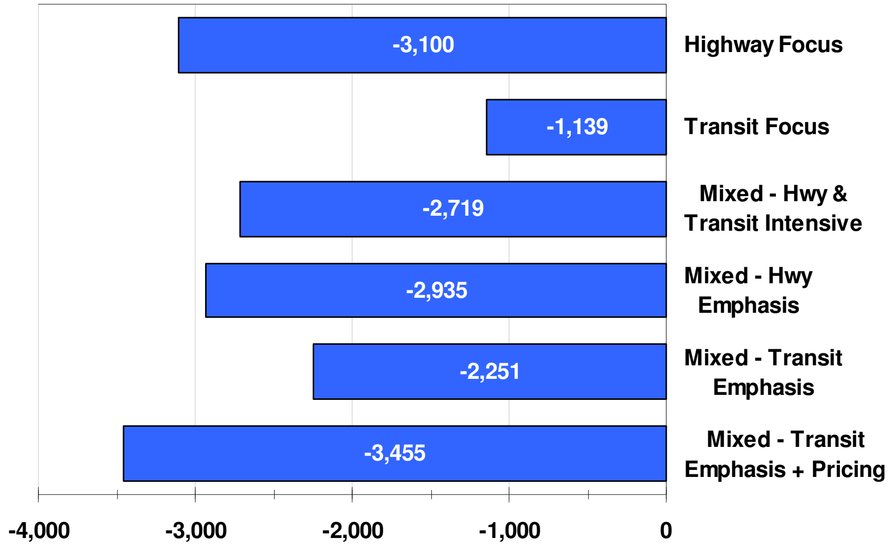
Metric: Annual Person-Hours of Delay Savings per $1 Million Total Capital Investment

The final economic analysis metric compares each scenario's primary benefit of travel time savings against the primary cost of capital investment. Figure 2-58 shows the annual quantity of delay reduction experienced by personal vehicle users, expressed in person-hours saved, and compares it to the level of capital investment for each scenario.[11] This yields a measure of the annual person-hours of vehicle delay savings per $1 million of total capital investment.[12]

[11] The annual savings are for 2025, and would be different for other years. This metric does not include changes in consumer surplus that is measured in overall benefits.

[12] Person-hours of delay savings applies to personal travel in the highway/auto mode only; it does not include delay savings accruing to transit users even though the scenarios include transit investments.

Figure 2-58: Total Annual Person-Hours of Delay Reduced per $1 Million Capital Investment



Funding Considerations in the Economic Analysis of Scenarios

It is important to view the economic analysis of the study scenarios as a data analysis exercise designed to help understand the relationships of costs and benefits in the context of congestion relief. Whereas the Pricing Focus Scenario provides revenues without projects to fund, the other scenarios provide projects without any funding to pay for them. The Pricing Focus Scenario is unique insofar as the investment in toll collection technologies and operations costs could be self-financed, and most of the toll revenues could actually be invested in other improvements. The analyses did not speculate as to what the best uses would be for toll revenues or how those revenue uses might impact travel behavior. Similarly, this study did not consider how transit and highway capital investments could be funded, or how the likely potential funding mechanisms may also influence travel demand.

Given the magnitude and scale of the investments analyzed in these scenarios, the taxes or fees sufficient to fund the projects could result in travel demand changes. For example, if even a small portion of the cost were funded by a tax or fee related to user costs— such as the gas tax — the resulting tax could potentially represent a substantial and sustained increase in travel costs, high enough to significantly reduce overall travel demand.[13] This effect would be similar to how tolls, when overlaid on the 2025 Baseline network in the Pricing Focus Scenario, manage travel demand to more efficiently allocate roadway capacity. If the generation of revenues to fund improvements actually lowered overall travel demand, this could ultimately result in the need for a different, somewhat smaller portfolio of investments at a lower cost.

Put another way, the scenarios considered may be so extensive that most of the currently conceivable ways for funding their construction could also have the indirect effect of mitigating some of their need. Large-scale actions require careful consideration of their impacts, including a feedback-loop that considers the entwined effects of how the public pays for and uses their

[13] For 2015, the horizon year for WSDOT's motor fuel tax revenue forecast, each penny of the current state-wide fuel tax is projected to generate $40 million in revenue. Substantial increases in the gas tax would generate less revenue per penny due to the price elasticity of demand effects — at higher prices, consumption drops.

transportation infrastructure, in order to strike the appropriate balance between relieving congestion and facilitating travel.

2.9 Environmental Review

An accurate assessment of environmental impacts can only be accomplished at the project level where detailed design information is available. Since developing project-level information is beyond the scope of this analysis, an environmental review was performed to compare the potential impacts of each of the scenarios, based on the information at hand. The purpose of the environmental review was to identify the primary environmental factors contributing to the costs of each scenario, as well as other impacts not easily quantified. Those impacts contributing to scenario costs (right-of-way, wetlands, and streams) are discussed above. Other impacts, such as air quality, noise, land use, and low-income/minority populations are discussed below.

Air Quality

Air quality impacts were assessed based on outputs from the travel demand forecast model, including link volumes, speeds, and travel distances. Emissions per mile traveled for carbon monoxide (CO), hydrocarbons (HC), oxides of nitrogen (NO_x), and carbon dioxide (CO_2) (a greenhouse gas) were calculated for each travel link based on the forecast operating speed for the link, emission factors from the Mobile 6.2 emissions model, and the carbon coefficient for gasoline. The number of vehicle miles traveled on each link was multiplied by the emissions per mile of travel for each link. Emissions of particulates and toxic air pollutants from automobiles are expected to vary between the scenarios similarly to the other pollutants.[14]

Emissions of CO will be less and emissions of HC are expected to be similar in 2025 compared to those that currently occur in the Puget Sound Region because of the increasingly strict emission standards being phased-in for automobiles. Emissions of NO_x and CO_2 are expected to increase because the increase in VMT under all scenarios is expected to be greater than any improvements in emission standards. If stricter greenhouse gas standards are imposed, then CO_2 emissions would be reduced compared to the calculations completed for this study; however, the relative difference in emissions between scenarios is expected to remain within a small range.

Air quality impacts are primarily associated with highway-oriented scenarios. Transit improvements and value pricing strategies are anticipated to reduce vehicle trips and/or vehicle miles traveled and therefore reduce air pollutant emissions. Air pollutant emissions would be the least under the Pricing Focus Scenario, with 4% less CO and 11% less HC than the 2025 Baseline Scenario. The Transit Focus Scenario would reduce air pollutant emissions by 1-2% from 2025 Baseline. The Highway Focus Scenario demonstrated mixed results; CO and NO_x would be 5-6% greater than for the baseline scenario because their emissions are largely dominated by changes in VMT, while hydrocarbon and CO_2 emissions would be 1-5% lower than the baseline because they are largely dominated by speed and congestion. The mixed scenarios are expected to result in emissions between those of the focus scenarios. With the exception of CO, air pollutant emissions with the mixed scenarios would be less than the 2025 Baseline Scenario. Increasing the level of transit investment in any scenario is expected to reduce air pollutant emissions, because transit use reduces VMT.

[14] The analysis was link-based, using the same general methodology as PSRC uses to complete regional conformity analysis (calculate speed on each link, calculate emission factor based on the modeled speed for the link, multiply emission factor for each link with the VMT for the link, then add up the entire network).

It is expected that all scenarios would meet regional conformity requirements, but would require additional analysis to demonstrate conformity.

Noise

Noise impacts were analyzed based on changes in VMT compared to the 2025 Baseline Scenario. While this approach does not identify all areas that would experience transportation noise impacts, it identifies locations where traffic noise would noticeably increase as a result of a scenario. Noise impacts are primarily associated with highway improvements, although steel-wheeled transit vehicles would also produce some noise impacts. Traffic noise levels near major facilities would be substantial under all scenarios, much as they are today.

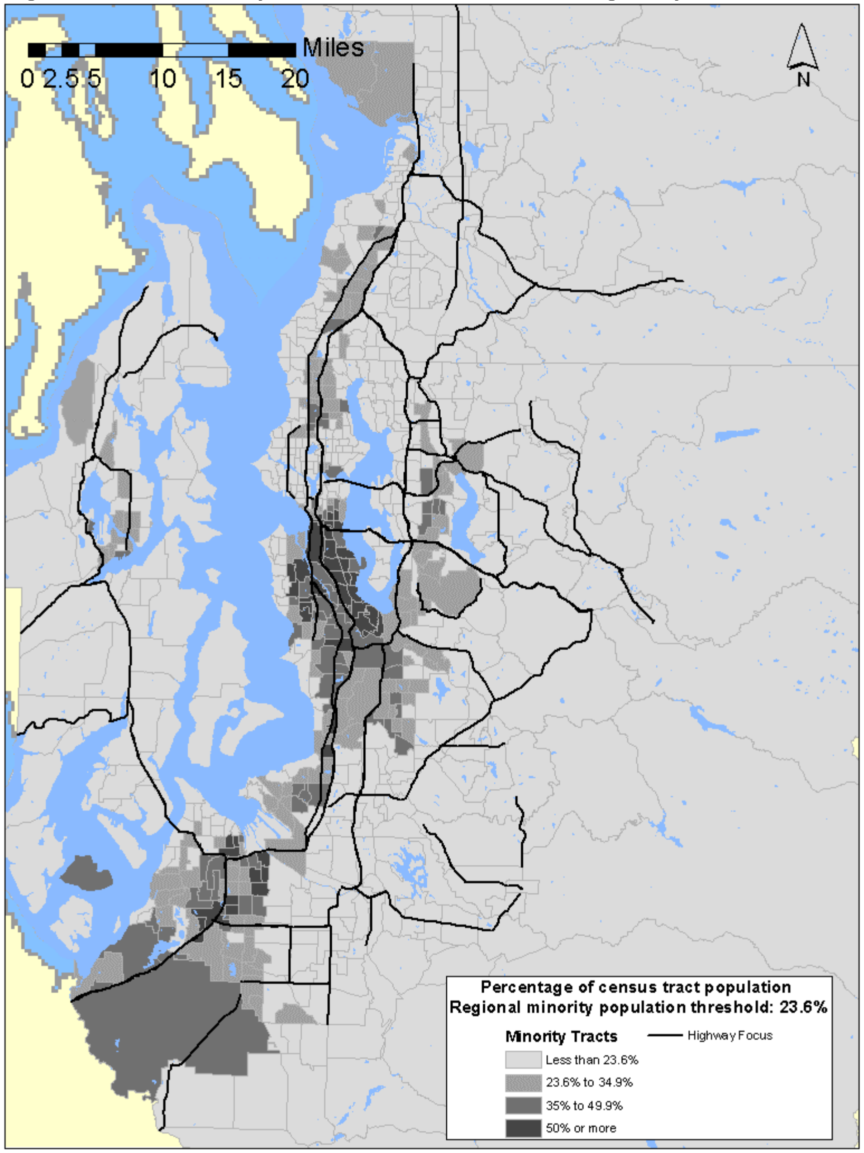
Each of the focus scenarios would create new noise impacts compared to the 2025 Baseline Scenario. The Highway Focus Scenario would have the most potential for creating noise impacts, caused by the addition of new facilities (i.e., additional lanes) where traffic volumes and speeds would increase. The Pricing Focus Scenario would also potentially result in noise impacts. In this case, the impacts may result from higher speeds on freeways and/or the redistribution of noise in accordance with the shifting to different travel routes and/or time of day, in response to value pricing. The mixed scenarios would also result in potential noise impacts, particularly along the routes where improvements were contemplated, although not as extensive as the Highway Focus Scenario. Transit improvements would not be anticipated to result in substantial traffic noise impacts at the system level, but could create localized noise impacts along new rail alignments.

Minority and Low-Income Populations

The focus of the minority and low-income population analysis was to generally identify the location of these populations within the region and to discuss potential impacts associated with each of the scenarios. Procedures for analyzing potential impacts in the central Puget Sound region were developed in consultation with WSDOT and the PSRC, and relied on data from the 2000 US Census. The analysis considered both direct and indirect impacts on these populations.

The central Puget Sound region has concentrated areas of low-income and/or minority communities. These areas are adjacent to many of the capacity improvements that were analyzed in the scenarios. To illustrate this point, Figure 2-59 and Figure 2-60 show where the Highway and Transit Focus scenarios would potentially interact with minority and low-income populations.

Figure 2-59: Minority Census Tracts and the Highway and Transit Focus Scenarios



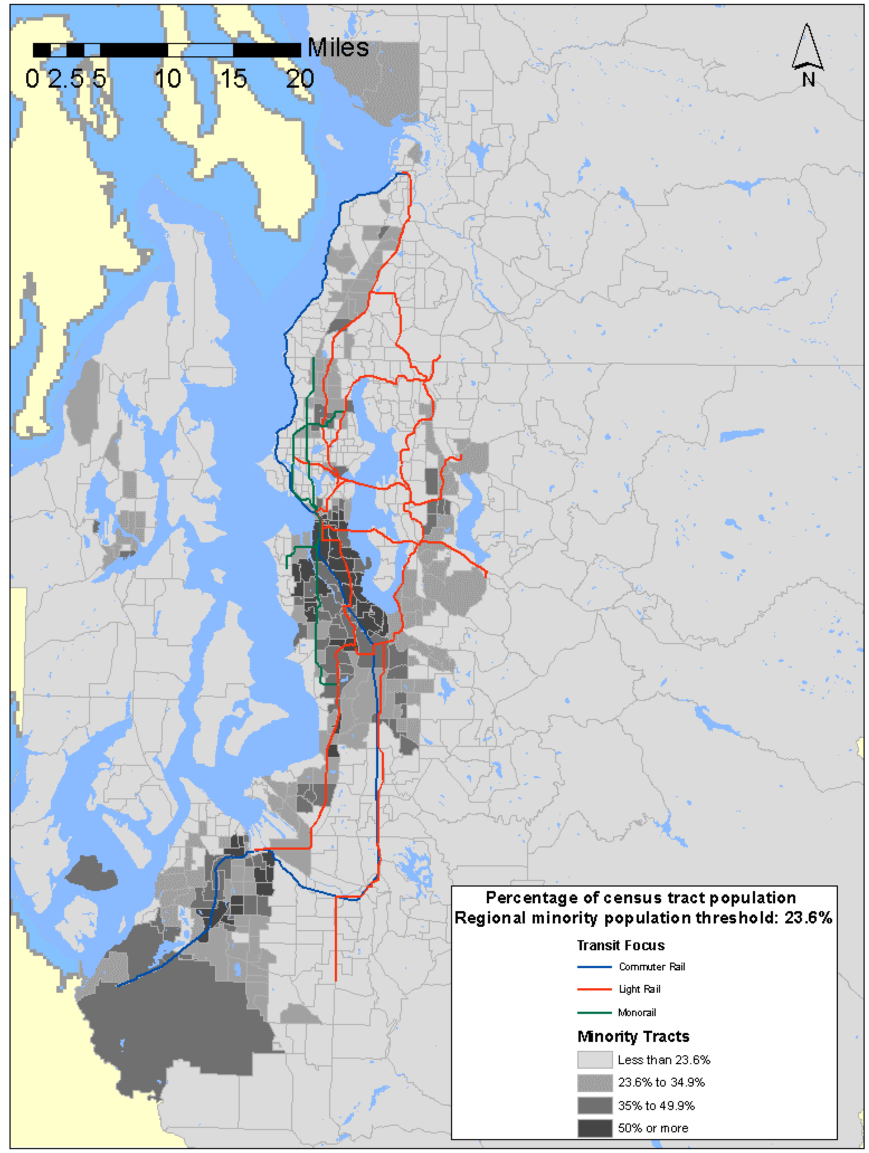
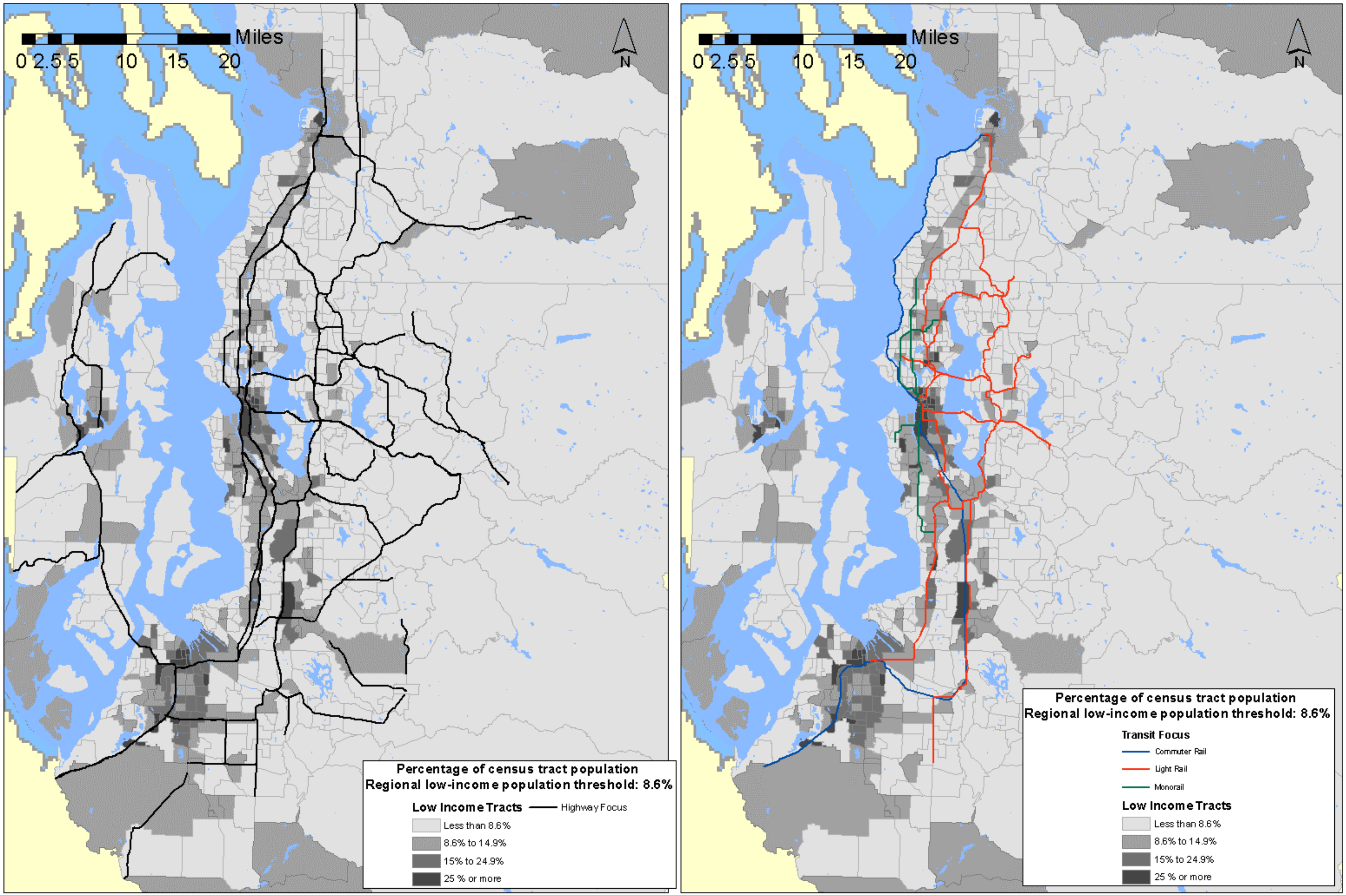


Figure 2-60: Low-Income Census Tracts and the Highway and Transit Focus Scenarios



The highway-oriented scenarios would have a higher potential for direct impacts in the form of right-of-way and property acquisition, increased noise levels, and impacts to air quality. The Highway Focus Scenario and the Highway Intensive Mixed Scenario show the greatest need for right-of-way acquisition, which could potentially affect low-income and minority populations living and/or working adjacent to the study corridors. Increases in noise and vehicle emissions also could impact nearby low-income and minority communities. Transit-related scenarios that include park-and-ride and maintenance facilities have a similar potential to impact low-income and minority populations. However, these impacts are anticipated to be smaller and more localized than the large-scale highway scenarios. More detailed information on both the nature of the improvement and the composition of the existing populations would be required to determine the extent of the impacts and whether or not low-income or minority communities would be disproportionately affected.

Each of the scenarios also has the potential for indirect benefits and impacts. Providing additional transportation capacity, whether in the form of highways or transit, provides improved access to employment, health care, shopping, and other community facilities that benefit all population groups. Offering more transit service tends to benefit persons who cannot drive or do not own cars. The highway-oriented scenarios provide travel time benefits to all population groups. Many minority and low-income community members rely on auto travel to reach available employment opportunities throughout the region.

Pricing effects on low-income and/or minority communities would depend on the variable toll structure implemented and the potential uses of the toll revenues. While users from all income groups have been shown to regularly make use of priced facilities[15], such facilities may be more frequently selected as a route of choice during peak travel times by those with

[15] State Route 91 Express Lanes (Orange County, CA)

Pricing and Equity

The concept of equity relating to the pricing of highways tends to focus on the relationship to income. However, other dimensions of equity may also be important, including modal and geographic equity. In the context of evaluating the equity of roadway pricing, a more practical application of the equity concept may be whether or not a pricing project distributes benefits and costs in an acceptable manner across different groups of people. This requires identifying: (1) Who are the affected groups of people? (2) Do all groups have access to the priced facilities? (3) What are the direct and indirect benefits of pricing?, and (4) What are the direct and indirect costs of pricing?

Research from several years of customer usage on two tolled facilities in Southern California (State Route 91 Express Lanes, Orange County and I-15 Express Lanes, San Diego County) suggests that people from all backgrounds value the reliable travel time and time savings that tolled routes provide compared to toll-free alternatives. On average, travelers' values of time — or willingness to pay tolls — tend to be correlated with wage rates or income segments, suggesting that those with higher incomes would be more likely to pay tolls. However, there are many instances in which this correlation does not hold.

Certain groups may receive substantial benefits by paying for a reliable travel time in order to avoid the greater costs of potentially being late for work or picking up children from daycare. The benefits of avoiding these costs may favor those in lower income groups. In San Diego, market research on the I-15 HOT lanes indicates that a majority of non-users approve of the concept of selling available space to single occupant vehicles in the former HOV lane. Some of this approval likely stems from indirect benefits that non-users receive in the form of marginal flow improvements in the general purpose lanes caused when other people shift into the HOT lanes. Other non-users may approve because they know they have the choice to use the HOT lane should circumstances arise.

The pricing concepts analyzed for the Congestion Relief Analysis study are far more extensive than any existing examples, and would thus, be likely to have more far-reaching effects. The uses of toll revenues generated by the scenarios with pricing were deliberately not determined other than to assume that they were put to some beneficial use. As such, the issue of whether or not benefits and costs would be distributed in an acceptable manner across different groups of people depends heavily on the assumption of how these revenues would be spent.

Any discussion of equity regarding pricing also needs to consider the multiple equity issues of the alternatives. Congestion in the absence of pricing imposes tremendous costs on travelers in terms of time that is lost forever. Investment in new infrastructure via other funding sources, such as the gas tax, has its own set of equity issues and impacts on travel behavior. For more information on pricing and equity considerations, see:

Weinstein, Asha and Gian-Claudia Sciara, *Assessing the Equity Implications of HOT Lanes,* Prepared for the Santa Clara Valley Transportation Authority, November 2004.

higher-valued trip purposes, for which there is some correlation to traveler income levels. This creates potential equity issues in the distribution of benefits and costs for different population groups, which may vary depending on how the toll revenues are put to use (refer to the previous *Pricing and Equity* box). Additional analysis would be required to more precisely address the effects of value pricing on minority and low-income populations.

Land Use

The interaction between land use and transportation is widely recognized; however, the relationship is complex and the focus of much debate. Impacts on land use were examined from three perspectives:
How well do scenarios meet current growth management requirements?
Do the scenarios match the plans and policies of jurisdictions?
What is the potential conversion of land to transportation uses?
This study evaluated how well different transportation scenarios serve the planned growth as described in regionally adopted land use plans. Most of the capacity added in the scenarios is located within the currently established urban growth areas. For example, approximately 83% of the lane miles added in the Highway Focus Scenario are located within existing urban growth areas (the percentages are higher for the mixed scenarios), with the remaining 17% added to connect the planned urban growth areas. This suggests that the added highway capacity would not necessarily induce significant growth outside established urban growth areas. However, it is conceivable that additional capacity could alter growth patterns within the urban growth boundaries. To quantify the potential land use changes would require an extensive modeling of transportation-land use interactions. Considering the number of scenarios analyzed and the nature of the study, the study team concluded that this iterative analysis would be more meaningful in a subsequent phase.

Land use was also analyzed from the perspective of consistency with regional plans and policies. For the most part, each of the highway and transit scenarios contains elements that are consistent both with the PSRC's Metropolitan Transportation Plan as well as the plans of local jurisdictions. The Highway Focus and Highway Emphasis Scenarios include the addition of several roadway segments that go well beyond currently adopted comprehensive plans. However, most of the additional roadway capacity would be consistent with level of service and concurrency policies that support reduced congestion. The mixed scenarios are the most likely to be consistent with land use plans and policies because they provide multiple transportation options and a more balanced system. The mixed scenarios offer more flexibility in providing appropriate modal improvements tailored to the planned land use and growth in different corridors.

The potential conversion of land to transportation uses can be assessed based upon the location and magnitude of the improvements. The highway-oriented scenarios have the most potential for conversion of existing land uses to roadway functions because of right- of-way needed for such improvements. The transit-oriented scenarios have less potential for direct land use impacts because they involve less conversion of existing land uses. The mixed scenarios are somewhere in between.

The effects of value pricing on land use have not been determined in this study and would depend on the magnitude of the variable value pricing structure and on how tolling revenues are put to use. Research on this emerging topic[16] indicates that value pricing strategies that result in shorter travel times could lead to either better access to currently congested land uses in developed areas (i.e. within urban growth areas), or to more dispersed new development. For example, using value pricing revenues to fund improved transit services could encourage growth within

[16] Transportation Research Board, *TCRP Report 95*, Chapter 14- Road Value Pricing, 2003

urban areas. Pricing could potentially lead to a number of indirect land use effects, including home and employment location decisions and the price of land.

Does this Analysis Capture the Effects of 'Induced Travel'?

The PSRC travel forecasting model accounts for several aspects of region-wide induced travel. Induced travel can be defined as an increase in daily travel resulting from an increase in transportation capacity. These effects are most commonly associated with the expansion of highway facilities.

The table below identifies six sources of induced travel and the estimated magnitude of their effect on regional travel. As indicated previously, from a region-wide perspective, the major source of induced travel is the lengthening of trips. Increases in residential and non-residential development (sources 1 and 2) are only likely if other conditions exist within a region to support economic development. Analysts have found that the impact of highway accessibility on the number of motorized person trips (source 3) is insignificant. The sixth source (shifts in travel route) results if travelers who have to reroute because of the highway improvement take a detour that lengthens the trip distance. This table shows that the regional forecasts have accounted for most significant sources of potential induced travel.

Source of Induced Travel	Magnitude of Effect on Induced Travel	Included in PSRC Model Forecasts?
1. Increase in residential development, i.e., person trip production (P) related development	Low to none	NO
2. Increase in non-residential development, i.e., person trip attraction (A) related development	Low to none	NO
3. Increase in number of daily motorized person trips per development unit	Very low	NO*
4. Increase in average motorized person trip distance due to origin/destination changes	High	YES
5. Increase in share of person travel by private motorized vehicles	Low to moderate	YES
6. Shift in vehicle travel to improved facilities from unimproved facilities within a corridor, or through an improved corridor due to diversion of traffic from other corridors	Low to moderate	YES

Source: Patrick DeCorla-Souza. "Induced Highway Travel: Transportation Policy Implications for Congested Metropolitan Areas." Transportation Quarterly, Vol 54.No.2, Spring 2000. Eno Transportation Foundation, Inc., Washington D.C., p.18.

* Specific data to support these changes were not available. The PSRC regularly conducts household surveys to update trip generation rates that account for changing accessibility within the region.

The substantial increase in roadway capacity provided in the highway-oriented scenarios could result in shifts in land use patterns and trip-making within the study area. These shifts were not quantified in this study. Previous studies of the impacts of major highway expansion on land use within the regional Urban Growth Areas (i.e., WSDOT, I-405 Corridor Program, Final EIS, June 2002) showed a clustering of development patterns within the region but limited effects on overall growth assumed by local and regional plans. The I-405 study concluded that the overall effects of induced demand were expected to be limited for the following reasons:

- Growth in population and employment is expected to increase daily travel demand by over 50%. This growth will leave minimal available capacity to generate additional induced demand.
- Although the duration of congestion may improve, congestion will still persist during the prime peak hours, providing limited incentives for travelers to generate additional trips or shift travel hours.
- Growth management policies in place within the region will limit the shifting of land use patterns and resulting trip-making in response to the highway expansion.

These I-405 study trends would be expected to hold for most of the scenarios tested in the Congestion Relief Analysis. Given the long-term horizon for the study (20 years), any effects of induced demand that are not already captured are likely to be very small in the context of overall regional growth. The transportation capacity analyzed in the CRA scenarios were developed to respond to planned growth within the region, and a high proportion of the added capacity was located within the current Urban Growth Areas. Further testing of land use effects of the scenarios may take place in subsequent phases of the study.

2.10 Additional Analyses

For the central Puget Sound region, three additional analyses were conducted to test enhancements to the preceding scenarios. Note that economic analysis was not conducted for these additional scenarios.

Efficiency Improvements (TDM and TSM)
Congestion relief can be partially achieved by improving efficiency in the transportation system. Emphasizing efficiency is important to ensure maximum productivity of the highway system (see text box on following page). Additional analyses were conducted to examine the effects of two efficiency measures:
Transportation Systems Management (TSM) – Strategies to improve the operating efficiency of the highway and transit system
Transportation Demand Management (TDM) – Strategies to reduce vehicular demand during peak travel time
The analysis focused on the incremental benefits that could be provided by implementing either TDM or TSM measures individually or in combination.

Strategies Tested
A number of TDM and TSM strategies have been implemented in the central Puget Sound region over the past several years. The benefits of these strategies have already been captured in the observed and forecasted traffic conditions documented in this study. The purpose of the additional analysis was to examine further benefits that could occur by implementing a more aggressive TDM/TSM program.

Three additional analyses were developed, as follows:

Test 1 – Transportation Systems Management
This test considered two TSM strategies:
Traffic Signal Coordination – Research on traffic signal coordination indicates that the effective lane capacity on arterials can be increased by 10.5 to 13.5% in corridors with high levels of congestion. In 2025, this level of congestion will occur on most major arterial routes in the central Puget Sound region. Acknowledging that traffic signal coordination is already fairly widespread in the region, the test assumed that the modeled lane capacity would be increased by 10% on all arterials with four or more total travel lanes.
Transit Signal Priority – Research on transit signal priority treatments indicates that providing active priority for transit at arterial intersections can increase transit speeds by up to 25%. To forecast this effect, adjustments were made to the transit travel time functions in the model to provide up to a 25% increase in transit speeds on arterials relative to GP traffic.
Both of these strategies can be considered optimistic assumptions, since many arterials within the region already contain some of these TSM features and, therefore, the actual delay reductions would likely be less than reported here.

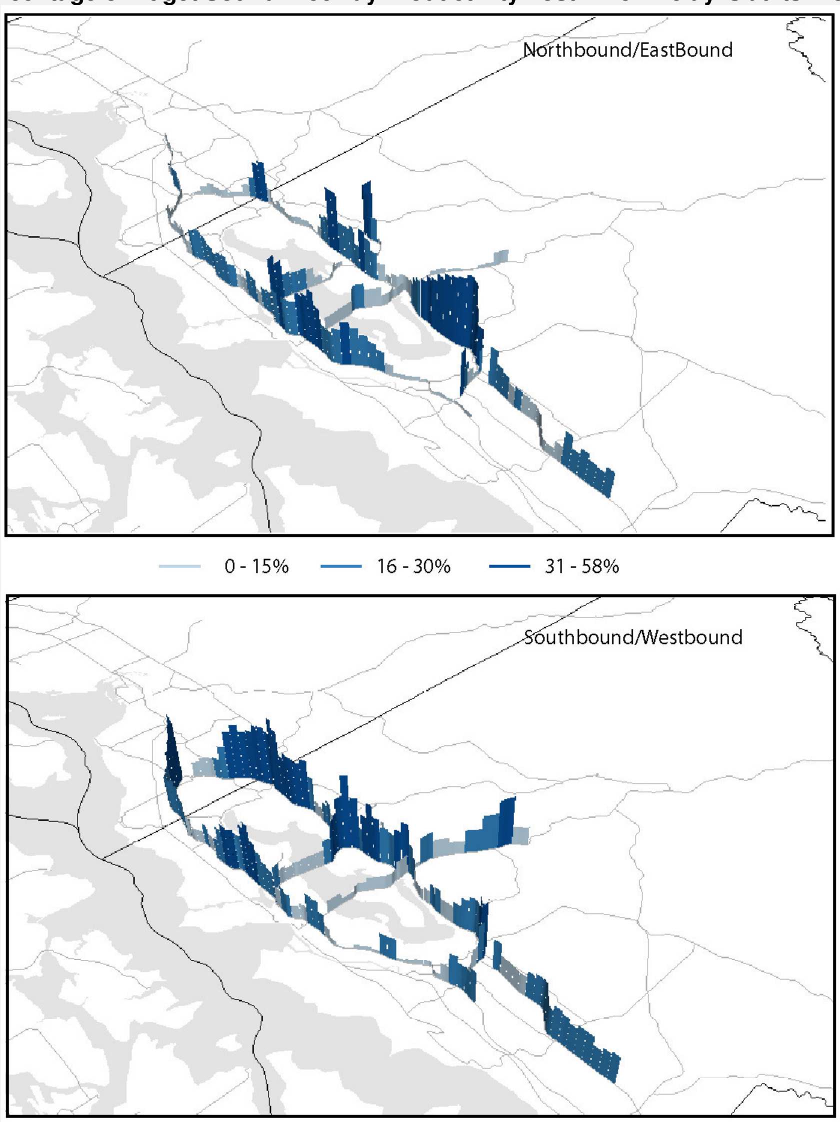
How Does Efficiency Affect Roadway Productivity?

Emphasizing efficiency is important to ensure maximum productivity of the highway system. As delay mounts, speeds drop. This is because drivers become more cautious. As conditions develop in this way, the *efficiency* of the highway, the number of vehicles passing the counting point in a given period of time, drops dramatically. For example, when congestion lowers a drivers' speed to 30 mph, the throughput on a freeway could fall to 1,700 vehicles per hour or lower. This compares to an efficient throughput of over 2,000 vehicles per hour. Efficiency can also be thought of as the *productivity* of the highway system.

WSDOT has studied the effects of delay on freeway productivity (WSDOT, *Bottlenecks and Chokepoints*, Draft Background Paper provided to Washington Transportation Commission, July 2004). The figures below show the existing percentage of general-purpose lane productivity lost during the heaviest travel time period on Central Puget Sound's primary highway corridors. The maps are shown by direction of travel. In this example, the heaviest productivity loss occurs on I-405 northbound just north of SR-167, where more than half of the capacity was lost due to congestion. In other words, less than one lane of capacity (out of two general purpose lanes) was available in a time that it is needed the most. A similar situation occurs on I-5 northbound through Seattle and I-405 southbound near the King/Snohomish County line.

These data lend support to the contention that efforts to improve highway efficiency could make major contributions to the productivity of our existing highway and freeway investments.

Percentage of Puget Sound Freeway Productivity Lost When Delay is at its Worst



Test 2 – Transportation Demand Management

This test considered the effects of reducing peak and daily vehicle trips by 3 to 5%. Research conducted as part of the I-405 Corridor Program showed that implementing a targeted corridor-level TDM program could result in vehicle trip reduction of approximately 5%. The vehicle trip reduction would result primarily from a mode shift to transit and HOV, and from shifting some trips out of the peak periods.

To model these effects, the EMME/2 trip table was factored to remove a portion of the home-based work trips. These work trips are the most likely to be affected by the TDM program. The test removed 20% of the home-based work person trips, which resulted in a 3.9% reduction in daily vehicle trips on the system.

Since the central Puget Sound region already has an active TDM program in place, achieving the assumed additional trip reductions would require a more aggressive implementation of both new programs and the expansion of existing programs.

Test 3 – Combined TSM/TDM

This test combined the effects of Tests 1 and 2 to examine a joint strategy of implementing TSM and TDM strategies. The TSM assumptions were the same as Test 1. The TDM assumptions used a slightly lower trip reduction target of 3% compared with Test 2. Otherwise, the analysis assumptions were the same.

Analysis Results

The TSM/TDM analyses were tested against the Transit Emphasis Mixed Scenario. This scenario was selected as a base for testing since it includes a mix of highway and transit investments. These findings were then generalized for the other mixed scenarios. Table 2-12 summarizes the results of the tests for several of the key analysis metrics.

Table 2-12: Results of TSM/TDM Tests*

Analysis Metric	Existing	Mixed Scenario: Transit Emphasis	Test		
			Test #1 TSM only	Test #2 TDM only	Test #3 TSM + TDM
Daily Vehicle Trips	8,545,600	12,326,300	12,310,700 (-0.1%)	11,842,800 (-3.9%)	11,948,700 (-3.1%)
Daily VMT	72,883,900	112,316,000	112,394,300 (+0.1%)	107,002,400 (-4.7%)	108,345,000 (-3.5%)
Vehicle Hours of Delay:					
● Daily	285,500	715,000	680,400 (-4.8%)	574,800 (-19.6%)	574,900 (-19.6%)
● PM Peak (2 hours)	125,300	366,800	347,300 (-5.3%)	295,900 (-19.3%)	295,200 (-19.5%)
Average Delay per Vehicle (min):					
● Daily	2.0	3.5	3.3 (-4.7%)	2.9 (-17.0%)	2.9 (-17.0%)
● PM Peak (2 hours)	4.7	9.2	8.7 (-5.3%)	7.4 (-19.4%)	7.4 (-19.4%)

(-X%) Percent change compared with the Transit Emphasis Mixed Scenario
* Since many arterials within the region already contain some TSM features, delay reductions that could be realized would be less than reported here.

Test #1 – TSM Only

The addition of traffic signal coordination and transit signal priority has minimal effect on the number of vehicle trips or VMT, but peak and daily delay are reduced by approximately 5%. This test demonstrates the potential of using the system most efficiently. The reduction in delay is comparable to deferring one to two years of delay caused by growth within the region. On a personal level, the savings in delay equates to approximately four hours per commuter per year, comparable to up to five days per year worth of travel time on a typical commute.

Test #2 – TDM Only

The 4% reduction in vehicle trips assumed with the TDM program results in close to a 20% reduction in vehicle hours of delay and average delay per vehicle. This trip reduction equals one to two years worth of regional growth but up to four years worth of travel delay growth. On a personal level, the delay savings is equivalent to 10 to 15 days of commute time.

Test #3 – Combined TSM and TDM

The combined TSM/TDM strategies result in comparable results to the TDM-only strategy (Test #2). The TSM actions to improve traffic flow in congested corridors work somewhat counter to the TDM program, which focuses on reducing vehicle trips in the same corridors. As a result, there is a slightly lower trip and VMT reduction but the same reduction in delay.

Figure 2-61 and Figure 2-62 depict the potential TSM/TDM combined effects on daily vehicle hours of delay and average delay per vehicle for the three mixed scenarios. The data for the Highway and Transit Intensive and the Highway Emphasis mixed scenarios were estimated from the results of the tests on the Transit Emphasis Mixed Scenario. This combined strategy could result in a 15- to 20% decrease in delay, pushing the average delay per vehicle for these scenarios closer to existing conditions. The total vehicle hours of delay remain considerably higher than existing conditions. This is primarily the result of increased trips associated with forecasted regional growth (refer to Table 2-12).

Figure 2-61: TSM/TDM Effects on Daily Vehicle Hours of Delay

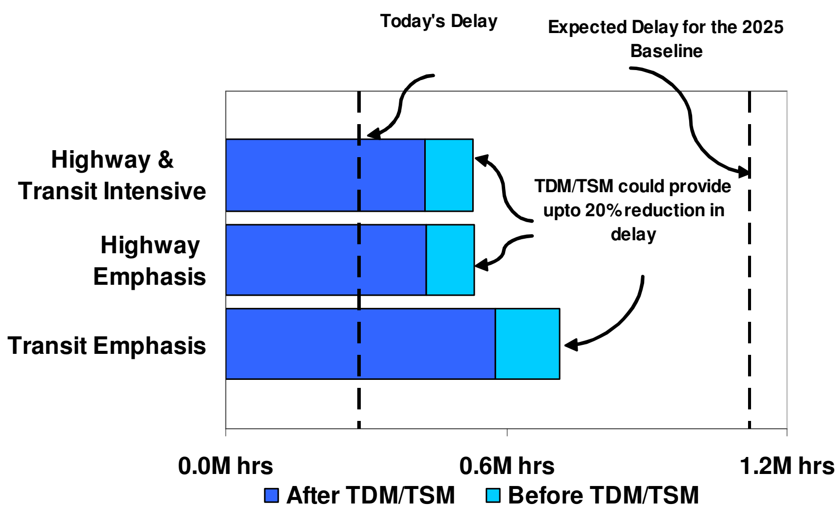
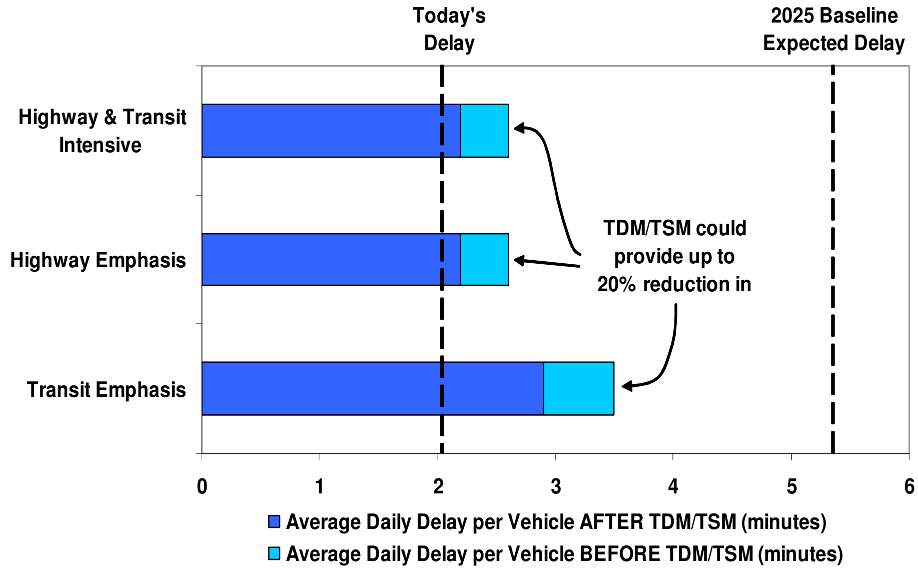


Figure 2-62: TSM/TDM Effects on Average Daily Delay per Vehicle



I-5 Parallel Corridor

Analyses were conducted to test the effects of creating a new and upgraded parallel freeway corridor in the central Puget Sound region. The purpose of the test was to identify whether a parallel corridor could provide additional congestion relief benefits. Two tests were performed:

1. Parallel corridor added to the 2025 Baseline Scenario – this test examined the effects of the parallel corridor by itself.
2. Parallel corridor added to the Transit Emphasis Mixed Scenario – this test examined the effects of the parallel corridor in addition to the Transit Emphasis Scenario. This scenario includes adding one GP lane on I-5 through Seattle and adding two lanes in each direction along the length of I-405.

Description of Parallel Corridor

The parallel corridor was selected to run north-south in the eastern portions of Pierce, King, and Snohomish counties. The corridor creates a four- to six-lane freeway corridor between Lakewood and Marysville with the following links, as shown in Figure 2-63:

Starts at the cross base highway in the south;

Goes over toward Canyon Road and turns north to meet SR 512;

SR 512 is widened over to SR 167;

SR 167 is widened north to SR 18;

SR 18 is widened to freeway north to I-90;

New freeway connection from I-90 to SR 2 in Monroe;

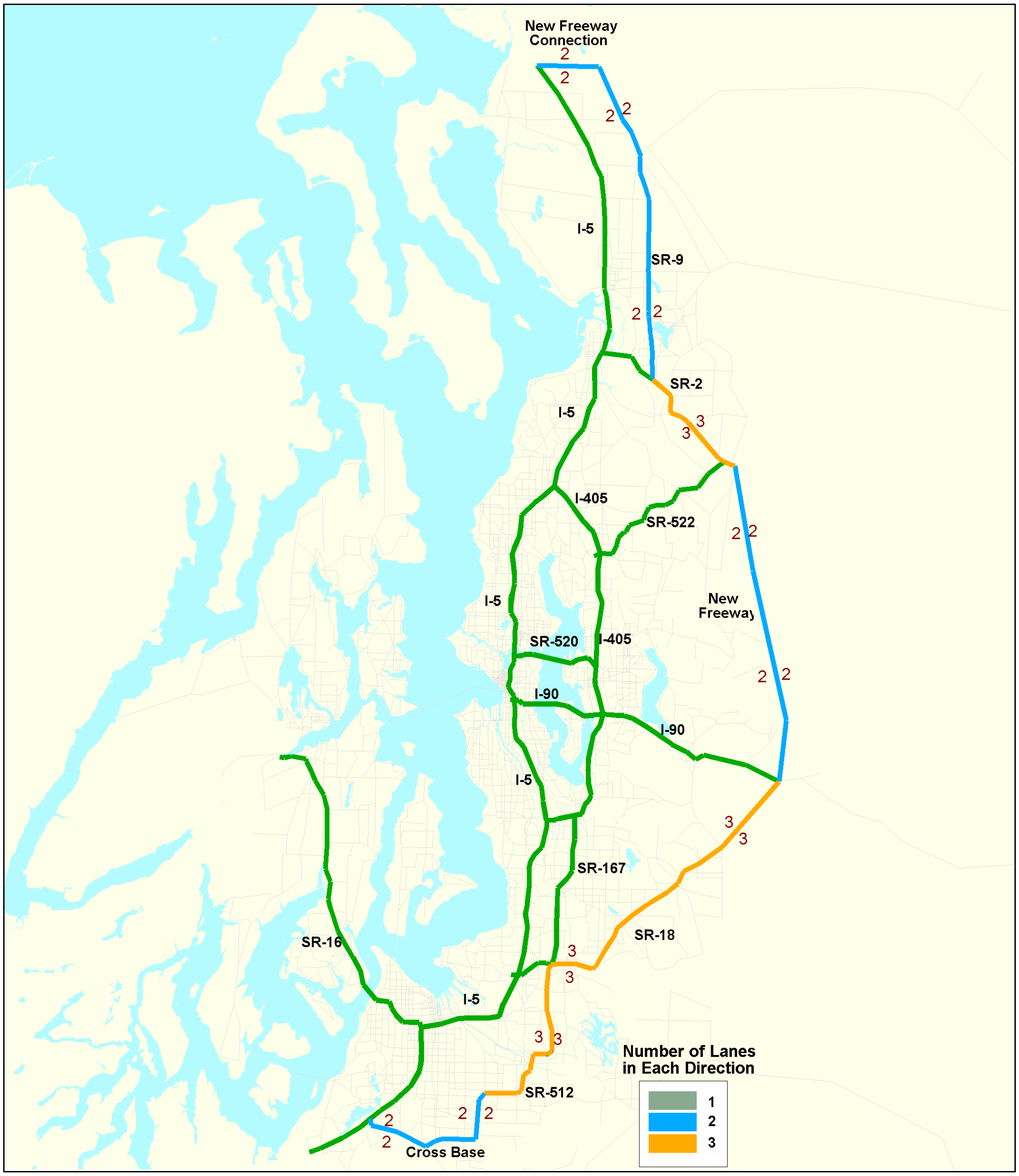
SR 2 is upgraded to freeway from Monroe to SR 9;

SR 9 is upgraded to freeway from SR 2 north; and

New freeway connection from SR 9 to I-5 near the Snohomish County/Skagit County Line.

The parallel corridor assumed that access to the facility would be limited to major arterial and freeway connections. For example, the new freeway connection from I-90 to SR 2 in Monroe assumed that there would be only one intermediate access point in this segment. This alignment is consistent with the Washington Commerce Corridor alignment opportunities[17] but does not extend south into Thurston County. The corridor alignment is also similar to what was studied previously in East King County[18] and as part of the I-405 Corridor Program[19].

Figure 2-63: Description of Parallel Corridor



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[17] WSDOT, *Washington Commerce Corridor Feasibility Study*, Alignment Opportunities Map, WSDOT Web Site, 2004

[18] WSDOT, *Corridor Needs Study for East King County*, Final Report, Office of Urban Mobility, June 2000.

[19] WSDOT, *I-405 Corridor Program,* Final Environmental Impact Statement, Office of Urban Mobility, June 2002

The Washington Commerce Corridor

The *Washington Commerce Corridor (WCC) Feasibility Study*, prepared for the Washington State Legislature (Wilber Smith 2004), includes an analysis of the willingness and ability of the private sector to build and operate the WCC corridor, a north-south alternative to Interstate-5 that would facilitate the movement of freight, goods, people, and utilities. The study area starts in the vicinity of Lewis County, extends north to the Canadian border, and contains Interstate 5, the mainline railroads, and major intercity pipeline facilities, which each operate on separate rights-of-way but roughly in the vicinity of Interstate 5 (I-5).

The study shows the corridor may be feasible only for truck travel in the southern section between I-90 and Chehalis. The study concluded that traffic patterns associated with both the auto and freight rail components do not fit the long haul, north-south orientation of the WCC and do not present a feasible option for the WCC. Several challenges remain as obstacles to its implementation, including the following:

Natural constraints. The alignment of the WCC will impact several small rural and agriculture based communities, and contains segments that have long-term impacts on species habitats and watershed areas.

Regulatory and land use issues. Many communities would need to modify their comprehensive plans. Several segments are located outside of established urban growth boundaries.

Environmental review processes. Current environmental processes in the state are not equipped to handle a project of this scope. This poses significant pre-construction risk for the private sector.

Costs. The high costs of the WCC undermine the feasibility of a wholly private sector approach to the WCC.

Legal and institutional issues. Various legislative actions would be required related to such public-private initiatives, powers granted to entities who would oversee the project planning and implementation of the corridor, and potential modifications to environmental processes.

The study recommended that future analyses focus on the feasibility of a public/private truck freight corridor between Seattle (I-90) and Chehalis, and possibly to Oregon.

The parallel corridor test adds several hundred lane miles of freeway within the region and reduces some arterial mileage by converting existing arterial routes to freeway standards. The change in lane miles for the two tests is shown in Table 2-13.

Table 2-13: Comparison of Highway Lane Miles for Parallel Corridor

Test 1 – Change in Lane Miles Compared with 2025 Baseline		Test 2 – Change in Lane Miles Compared with Transit Emphasis Scenario	
+ 510	Freeway	+ 440	Freeway
- 70	Arterial	- 90	Arterial
+ 440	Total Lane Miles	+ 350	Total Lane Miles

Analysis Results

The tests were conducted using the travel modeling process consistent with the Congestion Relief Analysis scenarios. Table 2-14 summarizes the following key analysis metrics used in evaluating the parallel corridor:

Traffic Volumes – Changes in daily traffic volumes for key roadway segments along the parallel corridor;
Travel Patterns – Proportion of traffic using the parallel corridor for longer-distance ‘through trips’;
Vehicle Miles of Travel – Daily and PM peak (two hours) for the region;
Vehicle Hours of Delay – Daily and PM peak (two hours) for the region; and
Congested Hours Per Day – Measured in 13 corridors.

Table 2-14: Comparison of Parallel Corridor Results

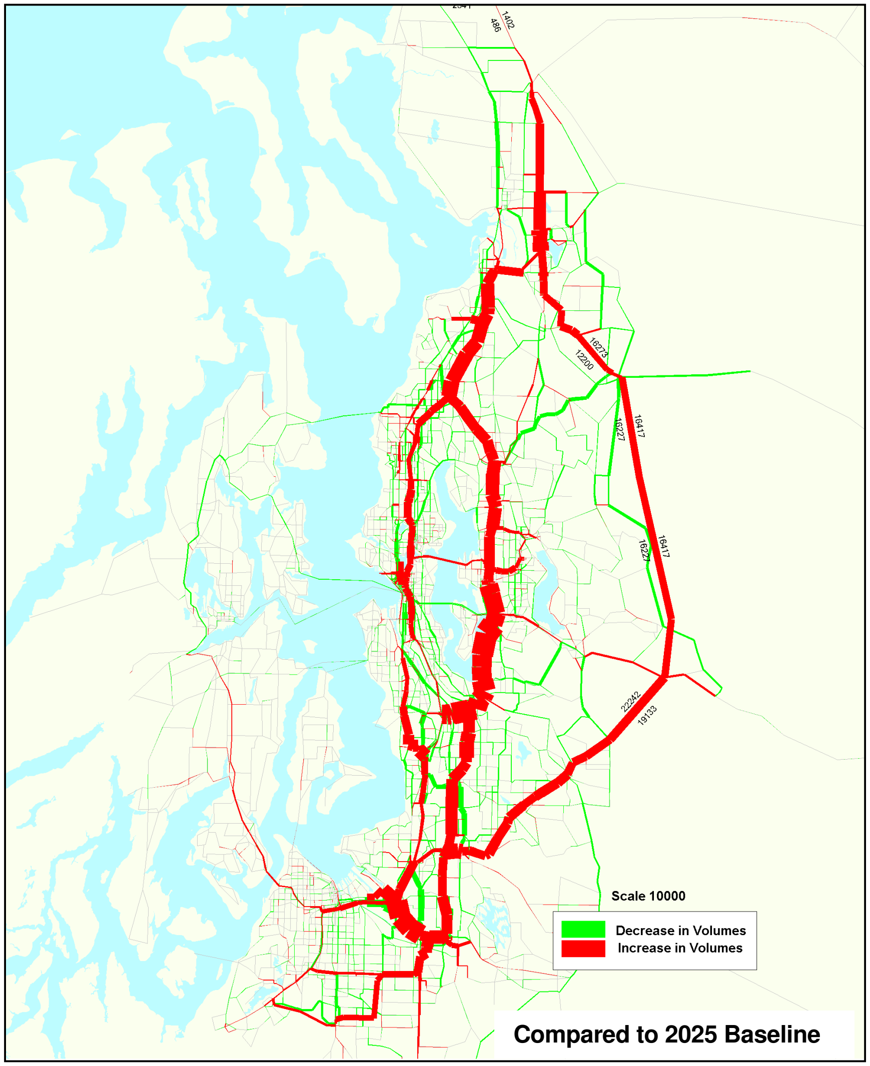
Analysis Metric	Test 1 – Parallel Corridor Compared with 2025 Baseline	Test 2 – Parallel Corridor Compared with Transit Emphasis (2025)
Traffic Volumes on Parallel Corridor		
North • SR 2 north of Monroe *Central* • North of I-90 *South* • West of SR 169	+66,700 +64,300 +80,600	+29,400 +32,700 +36,400
Travel Patterns		
	North – (SR 9 north of SR 2) 16% of traffic goes through to Pierce County 34% would go through to I-90 Central – (new fwy north of I-90) 38% of traffic travels between Snohomish and Pierce Counties South – (SR 18 east of SR 169) 18% of traffic travels between Snohomish and Pierce Counties 35% uses new freeway link north of I-90.	North – (SR 9 north of SR 2) 9% of traffic goes through to Pierce County 19% would go through to I-90 Central – (new fwy north of I-90) 28% of traffic travels between Snohomish and Pierce Counties South – (SR 18 east of SR 169) 10% of traffic travels between Snohomish and Pierce Counties 19% uses new freeway link north of I-90. Most disperses onto I-90.
Vehicle Miles of Travel • Daily • PM Peak Period	 +2.6% +2.7%	 +1.3% +1.7%
Vehicle Hours of Delay • Daily • PM Peak Period	 -20.5% -20.8%	 -11.2% -13.6%
Congested Hours per Day • 13 Corridor Averages • Individual Corridors	7.5 Total (-1.1 vs. 2025 Baseline) Congestion improvements to: I-5 Snohomish County (I-405 to Marysville); SR 18 (I-5 to I-90); SR 522 (I-405 to Monroe) I-5 (Central) and I-405 congestion improvements are very limited.	6.1 Total (-1.0 vs. Transit Emphasis) Congestion improvements to: I-5 Snohomish County (I-405 to Marysville); SR 18 (I-5 to I-90); SR 522 (I-405 to Monroe) I-5 (Central) and I-405 congestion improvements are very limited.

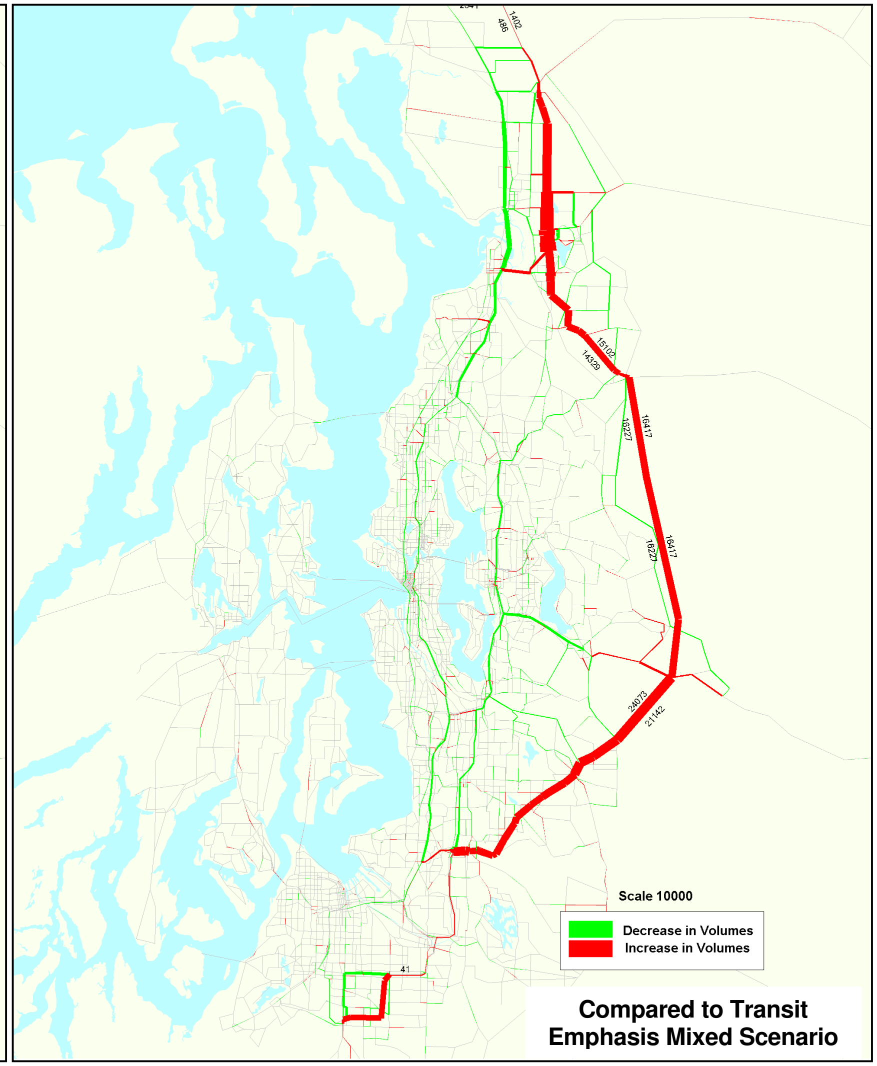
Traffic Volumes and Travel Patterns

The traffic shifts that occur with the parallel corridor are illustrated in Figure 2-64. The map on the left (Test 1) shows that the freeway corridor could attract 60,000 to 80,000 vehicles per day if it is added to the 2025 Baseline condition (i.e., if no other regional improvements are made). These forecasts (Test 1) are similar to results from the previous studies in East King County. The map on the right (Test 2) shows that the parallel corridor would attract only about half of this volume if the corridor were added to the Transit Emphasis Mixed Scenario network. The effects are reduced since this scenario's network includes highway capacity added to other regional freeways, including I-5 and I-405.

The parallel corridor has relatively small impacts on reducing traffic volumes on other regional facilities. The most notable reductions are along I-5 to the north and south of Seattle where the parallel corridor runs relatively close to I-5. There are minimal reductions in traffic volumes along

Figure 2-64: Daily Traffic Volume Shifts with Parallel Corridor





I-405 and I-5 through Seattle. This effect is true for both Tests 1 and 2. These shifts appear to be somewhat smaller than documented in the previous studies.

Usage of the parallel freeway corridor varies considerably in the north vs. central vs. south. Overall, only 10 to 20% of the users could be termed 'through' traffic, in terms of traveling through the corridor between Snohomish and Pierce counties. The vast majority of travelers would use the corridor for a few miles between major east-west connecting routes.

Vehicle Miles of Travel (VMT)

Tests 1 and 2 both show between 1 to 3% increases in regional vehicle miles of travel (VMT). Although these are small percentages, the magnitude of the change is relatively high when applied regionally.

Vehicle Hours of Delay

Although regional miles of travel increase, the analysis shows that there would be substantial reductions in regional vehicle hours of delay. The improvements to delay are highest with Test 1, with savings exceeding 20%. The savings for Test 2 are about half of Test 1, probably since much of the delay reduction was already accounted for by the capacity added in the Transit Emphasis Mixed Scenario.

Congested Hours per Day

Although overall regional delay is reduced, the number of hours of congestion on major corridors does not change greatly. Table 2-15 shows that the net improvement in freeway congestion is approximately one hour on average for each of the 13 corridors studied. Test 2 results in the lowest total congested hours per day, since it combines the parallel corridor with the capacity provided in the Transit Emphasis Mixed Scenario. These results imply that the benefits of the parallel corridor are dispersed throughout the region rather than focused on the major corridors.

Table 2-15: Corridor Congestion Hours of Delay per Day – Comparison for Parallel Corridor Tests

			Test #1		Test #2	
#	**Corridor**	**Existing (1998)**	**2025 Baseline**	**2025 Baseline + Parallel Corridor**	**2025 Mixed: Transit Emphasis**	**2025 Mixed: Transit Emphasis + Parallel Corridor**
1	I-5 Pierce Co.	4.0	6.5	6.1	5.2	5.2
2	I-5 So. King Co.	6.0	11.1	10.6	9.2	8.3
3a	I-5 Central (I-405 to I-90)	10.0	12.7	11.2	10.1	9.6
3b	I-5 Central (I-90 to SR-520)	8.0	9.7	9.1	8.6	8.2
3c	I-5 Central (SR-520 to I-405)	6.0	9.0	8.5	8.1	7.6
4	I-5 Snohomish Co.	4.0	8.5	6.8	7.7	5.6
5	I-405 South	7.0	8.1	8.1	7.1	6.8
6	I-405 North	5.0	9.0	8.2	6.9	6.2
7	I-90	4.0	6.3	6.0	6.1	6.0
8	SR-167	6.0	9.9	8.8	5.5	4.9
9	SR-16	4.0	4.5	4.8	4.9	5.0
10	SR-18	2.0	6.8	4.2	3.8	1.8
11	SR-522	3.0	9.7	8.3	6.3	4.7
12	I-90 East	3.0	4.0	3.8	3.3	3.2
13	SR-520	7.0	8.2	8.1	8.2	8.2
Corridor Average Freeways/Expressways		5.4	8.6	7.5	7.1	6.1

Regarding specific corridors, congestion is improved along I-5 through Snohomish County and along both SR 522 and SR 18. Most of the noticeable congestion improvements appear to be in the northern part of the region, where the new freeway corridor would be closest to I-5 and where travel demands are heavy. Minor congestion improvements would occur in the south, while congestion in the central part of the region would remain about the same. In particular, congestion levels on I-5 through Seattle and along I-405 would remain about the same.

High-Occupancy Toll (HOT) Lane System

Background

Analyses were conducted to consider the effects of creating a High Occupancy Toll (HOT) lane system in the central Puget Sound region. HOT lanes are defined as "limited-access, normally buffer-separated highway lanes that provide free or reduced cost access to qualifying HOVs, and also provide access to other paying vehicles not meeting passenger occupancy requirements".[20] HOT lanes use price and occupancy restrictions to manage the number of vehicles traveling on them, so that consistent volumes are maintained with uncongested travel times.

The introduction of value pricing on HOV lanes in the mid-1990s was tested as a way to address the underutilization of HOV lanes (e.g. the I-15 project in San Diego) or over-utilization of HOV lanes (e.g. the I-10 project in Houston). The growing use of value pricing as a means to manage demand is facilitated by the development of electronic toll collection (ETC) technology as an increasingly practical and inexpensive tool. Value pricing helps maximize the use of available capacity and still prioritize operation for HOV use.[21]

Other HOT Lane Studies

Local and national research has documented the potential benefits of HOT lanes. The primary benefits are that they provide the driving public with a new choice – premium and predictable travel conditions – on corridors where conditions would otherwise be congested. At the same time, they maximize the use of managed lanes – including HOV lanes – without causing traffic service to fall below desired levels. They also offer new revenue sources that can be used to support the construction of the HOT lanes themselves or other initiatives, such as improved transit service (Federal Highway Administration, ibid).

Studies of a two-lane HOT system along I-405 and SR 167 showed that HOT lanes could provide travel benefits in the central Puget Sound region. The I-405 Study (WSDOT, I-405 Management Land Evaluation Technical Memorandum, August 2002) analyzed both priced and non-priced lanes and concluded the following:

The managed system provided comparable or better person throughput and improved corridor speeds compared to a single HOV (3+) lane concept.

Pricing of the lanes offers opportunities for better managing the use of any spare capacity that might exist in the system

The SR 167 HOT Lane Study (WSDOT, HOT Lanes Pilot Project Study Draft Report, October 2003) examined conversion of an HOV lane to a single HOT lane. The technical analyses documented that the HOT lanes would move more vehicles than the HOV lane, without decreasing the overall speed in the lanes. The HOT lanes were found to have a minimal impact on speeds in the adjacent GP lanes. While the total freeway volume changes were estimated to be relatively small, the freeway could operate more efficiently as a managed facility.

HOT Lane Network

A HOT lane network for this analysis was defined as two lanes in each direction, on a freeway comprising of an existing HOV lane and the adjacent GP lane (SR 16 is an exception, where only the HOV lane is assumed to be a HOT lane). For testing purposes, the HOT lane network was built as follows:

1. Start with the Transit Emphasis Mixed Scenario; this scenario includes limited freeway expansion and extensive transit facilities and services.
2. Identify freeway segments for which at least one lane was added in the Transit Emphasis Mixed Scenario and where an HOV lane exists (see Figure 2-65). The rationale used was

[20] Federal Highway Administration, *A Guide for HOT Lane Development*, March 2003

[21] TRB HOV Systems Committee, *Managed Lanes: Strategies Related to HOV/HOT*, draft White Paper, June 2003

that the HOT lanes should be created through a combination of HOV lanes and newly added freeway lanes. The following corridors met this criterion:

I-5 from SR 512 to US-2;
SR 16 from I-5 to Olympic Drive (one lane each direction);
I-90 from I-5 to SR 900;
SR 167 from SR 512 to I-405; and
I-405 from I-5 (south) to I-5 (north).

HOT Lane Analysis

Critical to analysis of the HOT lane system is the assumption related to the vehicle throughput that a congested GP lane could provide. Throughput is different than demand, since throughput is constrained by the available capacity in the system.

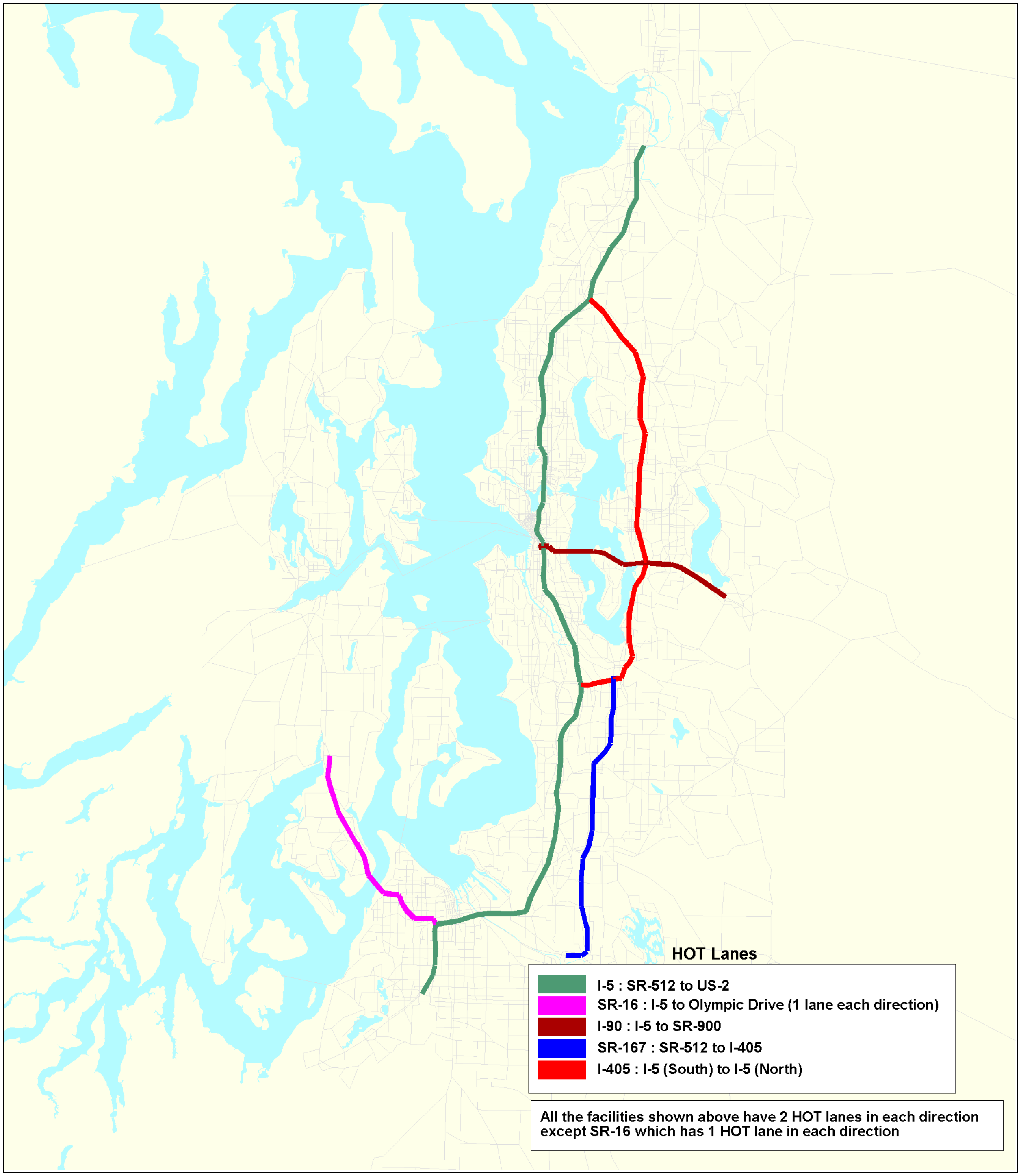
When traffic volumes exceed available capacity, the facility breaks down and vehicle speeds decrease. Observations of freeway throughput on Puget Sound freeways indicate that 2,100 vehicles per hour (vph) per lane is obtainable, but not sustainable. When demand for travel exceeds the 2,100 vph threshold, congestion ensues, resulting in highly unstable freeway flow. As the lane's congestion increases to the point that the speed drops below 45 mph, the actual throughput starts to drop. On Puget Sound freeways where real-time data are available, it is generally observed that for every ten-mph drop in speed there is an approximate 20% drop in throughput.

The HOT lane analysis assumed the following:

The two HOT lanes would operate at a maximum throughput of 1,900 vph per lane at a constant speed of 60 mph. The HOT lane volumes would include the forecasted HOV 3+ vehicles plus SOV and HOV 2+ vehicles that would switch from the GP lanes into the HOT lanes. The value pricing of the lanes would ensure that the 1,900 vph per lane capacity level is not exceeded.
The remaining GP lanes would continue to operate at the same speed predicted by the travel model. If the speed is less than 50 mph, the throughput of the GP lanes would be reduced by 20% for each ten- mph drop in speed. For example, if the GP lanes were operating at 30 mph, the volume throughput would be reduced by 40%.
The analysis time chosen for this test was the PM peak (two hour) period.
No revenue estimation analysis was included.

The HOT lane analysis then calculated the change in total vehicle delay between the HOT lane and HOV lane system. Delay was estimated as any reduction in speed below 60 mph on the system. Finally, the change in vehicle throughput was calculated between the two systems. For convenience, this change in throughput was converted to an equivalent change in the number of freeway lanes. This was considered to be the change in efficiency of the freeway.

Figure 2-65: HOT Lane Network



HOT Lane Results

The analysis method outlined above was applied to the designated HOT lane corridors using data from the Transit Emphasis Mixed Scenario. This scenario was chosen as a base for testing, since it includes some freeway capacity addition that would be conducive to a HOT-lane program, while enough traffic congestion would remain to provide incentives for HOT lane users. Table 2-16 summarizes the results of this sketch analysis.

The calculation of Vehicle Hours of Delay shown in Table 2-16 cannot be directly compared with vehicle delay computed elsewhere in this study, since the analysis assumptions were slightly different. However, on a generalized level the HOT lane system appears to reduce peak period delay by approximately 5 to 10% using these data. Similarly, there could be a net increase in freeway efficiency of approximately one to two equivalent lanes of GP travel. For travelers, the HOT lane system offers the opportunity for substantial time savings, albeit for a price.

Table 2-16: HOT Lane Sketch Analysis Results (PM Two-Hour Peak)

Corridors	Vehicle Hours of Delay (Change vs. Transit Emphasis Mixed Scenario)	Equivalent Change in Number of GP Lanes (Total Both Directions)
I-5 from SR 512 to I-405 South	-3,021	+1.2
I-5 from I-405 South to I-405 North	-3,368	+1.0
I-5 from I-405 North to US 2	-1,458	+1.4
SR 16 from I-5 to Olympic Drive	-224	+0.8
I-90 from I-5 to SR 900	-3,391	+1.8
SR 167 from SR 512 to I-405	-2,147	+1.4
I-405	-4,480	+1.3

Note: Data developed in comparison with the Transit Emphasis Mixed Scenario

2.11 Next Steps

The results of the analysis for the central Puget Sound region provide information that may be useful for future planning efforts. During the course of the analysis, several issues arose that could not be fully explored in the context of the identified scope of the study. These issues include:

- Potential effects of congestion strategies on land use allocation and mix;
- Refinements to the benefit-cost methodology, such as multiple future years;
- Effects of value pricing on time-of-day and transit ridership behavior;
- Effects of HOT lanes (beyond the sketch planning level conducted in this study);
- Corridor effects of TDM strategies related to land use characteristics; and
- Effects of potential funding strategies on overall travel demand and travel patterns.

These topics may be considered in subsequent phases of the Congestion Relief Analysis or other planning studies.